

**WATER QUALITY PROGRAM  
Bromide Expert Panel**

**MEETING PACKAGE**

**ADDENDUM**

September 8-9, 1998  
Sacramento Convention Center  
1400 J Street, Room 103  
Sacramento, California



CALFED  
BAY-DELTA  
PROGRAM

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# **Water Treatment Plants Using State Water Project Supply**

**STATE PROJECT WATER PLANTS**

<sup>2</sup>  
D - 0 3 5 8 4 9

## Sources

By conducting a fax survey, information was collected from WTPs that currently treat raw SPW, regardless of whether the plant had additional water sources. 43 WTPs treat SPW, however, only 41 plants responded to our survey and therefore only 41 plants were included in this project. A list of the SPW plants is given below. Plants which purchase treated SPW from other agencies and subsequently treat and distribute it were not included to avoid redundancy in cost calculations.

## Data Collected

Each plant provided treatment process information including average and peak flow, influent water quality, unit processes, chemical additions and tank/basin volumes (or detention times). A majority of the plant information was verified with staff at the DWR. Average values for water quality and chemical doses were used in all calculations. In a few cases where influent water quality information or basin volumes could not be attained, default values were used.

Plant Number	Plant Name and Location
1	Del Valle WTP Zone 7 Water Agency 601 E. Valencia Rd. Livermore, CA 94550
2	Patterson Pass WTP Zone 7 Water Agency 8750 Patterson Pass Rd. Livermore, CA 94550
3	WTP 2 Alameda County Water District 42436 Mission Blvd. Fremont, CA 94539
4	Rio Vista WTP Castaic Lake Water Agency 27234 Bouquet Canyon Rd.

	Santa Clarita, CA 91350
5	Earl Schmidt WTP Castaic Lake Water Agency Lake Hughes Rd. Castaic, CA
6	Bollman WTP Contra Costa Water District 2015 Bates Ave. Concord, CA 94520
7	J. Jensen FP Metropolitan Water District of Southern California 13100 Balboa Blvd. Granada Hills, CA 91344
8	R.B. Dicmer FP Metropolitan Water District of Southern California 3972 Valley View Ave. Yorba Linda, CA 92686
9	R.A. Skinner FP 1 Metropolitan Water District of Southern California 33740 Borel Road Winchester, CA 92396
10	R.A. Skinner FP 2 Metropolitan Water District of Southern California 33740 Borel Road Winchester, CA 92396
11	F.E. Weymouth FP Metropolitan Water District of Southern California 700 Moreno Filtration Ave. La Verne, CA 91750
12	H.J. Mills FP Metropolitan Water District of Southern California 550 E. Alessandro Blvd. Riverside, CA 92507
13	North Bay Regional WTP City of Fairfield/City of Vacaville

	5110 Peabody Rd. Vacaville, CA 95687
14	Santa Teresa WTP Santa Clara Valley Water District 5750 Almaden Expy San Jose, CA 95118
15	Rinconada WTP Santa Clara Valley Water District 5750 Almaden Expy San Jose, CA 95118
16	Penetencia WTP Santa Clara Valley Water District 5750 Almaden Expy San Jose, CA 95118
17	Fleming Hill WTP City of Vallejo 202 Fleming Hill Rd. Vallejo, CA 94590
18	Travis AFB WTP City of Vallejo Travis AFB Travis, CA 94535
19	American Canyon WTP City of American Canyon Lynch Rd. American Canyon, CA
20	Henry C. Garnett Water Purification Plant Kern County Water Agency 811 Nadine Ln. Bakersfield, CA 93308
21	Quartz Hill WTP Antelope Valley-East Kern Water Agency 6500 W. Ave. N. Palmdale, CA 93551

22	<p>Eastside WTP                      Antelope Valley-East Kern Water Agency                      35261 116<sup>th</sup> St. E.                      Pearlblossom, CA 93553</p>
23	<p>Acton WTP                      Antelope Valley-East Kern Water Agency                      36007 N. Sierra Hwy.                      Palmdale, CA 93550</p>
24	<p>Rosamond WTP                      Antelope Valley-East Kern Water Agency                      3600 35<sup>th</sup> St. W.                      Rosamond, CA 93560</p>
25	<p>Benecia WTP                      City of Benecia                      100 Water Way                      Benecia, CA 94510</p>
26	<p>Palmdale WTP                      Palmdale Water District                      700 East Ave. S.                      Palmdale, CA 93550</p>
27	<p>Crestline WTP                      Crestline-Lake Arrowhead Water Agency                      24116 Crest Forest Dr.                      Crestline, CA 92325</p>
28	<p>Polonio Pass WTP                      Central Coast Authority                      4 mi. E. Cholame                      Hwy. 46                      Chandon, CA 93461</p>
29	<p>Jameson Canyon WTP                      City of Napa                      Public Works Department                      270 Lynch road                      P.O. Box 660                      Napa, CA 94558</p>



30	Lake Bard Filtration Plant Calleguas Municipal Water District 2100 Olsen Road Thousand Oaks, CA 91360
31	Lloyd W. Michael WTP Cucamonga County Water District 5815 Etiwanda Ave. Etiwanda, CA 91739
32	Escondido-Vista WTP City of Escondido 3440 E. Valley Pkwy Escondido, CA 92027
33	R. M. Levy Treatment Plant Helix Water District 9550 Lake Jennings Park Road Lakeside, CA 92040-3513
34	Los Angeles Department of Water and Power Los Angeles Aqueduct Filtration Plant 13101 Sepulveda Blvd. Sylmar, CA 91342
35	Robert A. Weese Filtration Plant City of Oceanside (300 N. Coast Hwy., Oceanside, CA 92054) 3885 Silver Leaf Lane Vista, CA 92083
36	Alvarado Filtration Plant City of San Diego 5546 Kiowa Dr. La Mesa, CA 91942
37	Miramar Filtration Plant City of San Diego 10710 Scripps Lake Dr. San Diego, CA 92131
38	Otay Filtration Plant City of San Diego 1500 Wueste Road

	Chula Vista, CA 91910
39	Robert A. Perdue WTP Sweetwater Authority 100 Lakeview Avenue Spring Valley, CA 91913
40	Miramar Treatment Plant Three Valleys Municipal Water District 1021 Miramar Ave. Claremont, CA 91711
41	Water Facilities Authority 1775 N. Benson Avenue Upland, CA 91784

**AVERAGE FLOW INPUT FILE**

DNR Input File:

Estimate Name

Point #	Instrument	Ave Flow	Peak Flow	pH	Temp	Low Temp	TOC	UV	Br	AK	Ca	Hard	Na-S	NTU	Chlorine	SPW Log	End	Process	Volume	TSS
1		16	46	7.8	17.2	10	3	0.1	0.1	80	100	120	0.01	14		1		ALUM		
2		9	9	6.8	19.2	10	3	0.1	0.1	96	40	120	0.01	3.7		1		FLORINE		
3		18	18	7.5	16	10	3	0.1	0.1	70	100	120	0.01	10		1		OZONE		
4		15	15	8	16	10	3	0.1	0.1	90	100	170	0.01	2		1		OZONE		
5		15	15	8	16	10	3	0.1	0.1	90	100	170	0.01	2		1		ALUM		
6		30	30	8	17	10	3	0.1	0.1	60	70	70	0.01	4		1		ALUM		
7		325	325	7.81	14.3	10	3	0.1	0.1	87	110	119	0.01	0.12		1		FLORINE		
8		41.175	41.175	8.19	21.2	10	3	0.1	0.1	133	156	258	0.01	2.01		1		FLORINE		
9		17.812	17.812	8.33	22.9	10	3	0.1	0.1	121	157	280	0.01	2.28		1		FLORINE		
10		14.362	14.362	8.32	23.8	10	3	0.1	0.1	119	156	259	0.01	1.96		1		FLORINE		
11		35.42	35.42	8.2	20.9	10	3	0.1	0.1	109	153	254	0.01	2.77		1		FLORINE		
12		32.67	32.67	8.03	19	10	3	0.1	0.1	76	60	108	0.01	5.31		1		FLORINE		
13		9	9	7.8	16	10	3	0.1	0.1	90	100	170	0.01	36		1		OZONE		
14		2.5	2.5	7.8	17.7	10	3	0.1	0.1	82	50	108	0.01	2.8		1		FLORINE		
15		24	24	7.8	17.4	10	3	0.1	0.1	77	56	102	0.01	4.5		1		ALUM		
16		19	19	8	18.2	10	3	0.1	0.1	78	57	98	0.01	7.7		1		FLORINE		
17		7.2	7.2	8.1	18.4	10	3	0.1	0.1	117	53.2	125	0.01	17.3		1		FLORINE		
18		3.5	3.5	7.71	19	10	3	0.1	0.1	94	48	97	0.01	39		1		SODIUM HYDROXIDE		
19		1.872	1.872	7.25	15	10	3	0.1	0.1	80	25	70	0.01	100		1		ALUM		
20		1.25	1.25	8.5	19	10	3	0.1	0.1	120	120	140	0.01	6		1		PERMANGANATE		
21		25	25	8.1	15	10	3	0.1	0.1	75	15	75	0.01	6		1		FLORINE		
22		4	4	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5		1		FLORINE		
23		4	4	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5		1		FLORINE		
24		7	7	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5		1		FLORINE		
25		5	5	7.2	15	10	3	0.1	0.1	97	18	76	0.01	40		1		ALUM		
26		16	16	7.8	21	10	3	0.1	0.1	50	100	120	0.01	10		1		ALUM		
27		0.43	0.43	7.78	15.8	10	3	0.1	0.1	75	50	94	0.01	7.83		1		FLORINE		
28		25	25	8.2	18.5	10	3	0.1	0.1	60	40	90	0.01	10		1		ALUM		
29		10	10	8	18	10	3	0.1	0.1	60	100	120	0.01	5		1		SODIUM HYDROXIDE		
30		30	30	7.8	22	10	3	0.1	0.1	109	42	183	0.01	2.5		1		OZONE		
31		15	15	8.1	18.5	10	3	0.1	0.1	50	50	170	0.01	8		1		FLORINE		
32		11.25	11.25	7.75	20.5	10	3	0.1	0.1	117	129	220	0.01	7		1		FLORINE		
33		8	8	8.2	19.9	10	3	0.1	0.1	115	276	276	0.01	2		1		FLORINE		
34		115.63	115.63	8.2	16	10	3	0.1	0.1	120	60	90	0.01	2.7		1		OZONE		
35		2.805	2.805	8.27	20	10	3	0.1	0.1	101	135	224	0.01	2.6		1		FLORINE		
36		9.8	9.8	8.1	20	10	3	0.1	0.1	125	145	225	0.01	2		1		FLORINE		
37		12	12	8.2	20	10	3	0.1	0.1	125	175	280	0.01	2		1		ALUM		
38		2.6	2.6	7.9	20	10	3	0.1	0.1	155	125	187	0.01	3		1		ALUM		
39		9	9	7.67	25	10	3	0.1	0.1	157	144	264	0.01	12.3		1		FLORINE		
40		18	18	7.5	16	10	3	0.1	0.1	70	18	83	0.01	3		1		FLORINE		
41		31	31	8.05	17.8	10	3	0.1	0.1	70	20	85	0.01	3		1		FLORINE		

SLV D1

9-3-98 : 3:15PM : MALCOLM PIRNIE, PHO-

916 736 3714: #10/22

D-035857

D-035857

D - 0 3 5 8 5 8

D-0-30 : 0:15PM : MALCOLM FIRNIE, PHO-

916 736 3714;#11/22

TTD	Occur	End	Process	Volume	TSO	TTD	Occur	End	Process	Volume	TSO	TTD	Occur	End
31			ALUM	0.038869	1	0.1			ALUM	0.016883	1	0.1		SE
21			ALUM			35.8			ALUM					FL
25		CONTRACT T	0.4824	1	0.5				ALUM					SE
15		CONTRACT T	0.0825	1	0.5				ALUM					SE
2		APD MI	0.0104	1	0.1				FLOCCULAT	0.6044	1	0.1		SE
40		APD MI	0.104187	1	0.1				FLOCCULAT	1.04	1	0.1		SE
19		ALUM			2.7				APD MI	0.1172	1	0.1		SE
22		ALUM			4.1				APD MI	0.2116	1	0.1		SE
35		ALUM			5.6				APD MI	0.0847	1	0.1		SE
35		ALUM			5.3				APD MI	0.0722	1	0.1		SE
29		ALUM			3.8				APD MI	0.1787	1	0.1		SE
28		ALUM			4.6				APD MI	0.0228	1	0.1		SE
15		CONTRACT T	0.10773	1	0.5				OZONE			0.5		SE
2		ALUM			32				APD MI	0.0347	1	0.1		SE
35		APD MI	0.0278	1	0.1				SETTLING B	8.2	1	0.3		SE
25		ALUM			30				APD MI	0.0139	1	0.1		SE
11		OZONE			0.6				CONTRACT T	0.078	1	0.5		SE
35		ALUM			1.3				OZONE			15		SE
80		APD MI	0.0014	1	0.1				FLOCCULAT	0.0308	1	0.1		SE
15		ALUM			30				APD MI	0.0825	1	0.1		SE
28		ALUM			46				APD MI	0.22584	1	0.1		SE
28		ALUM			46				APD MI	0.034122	1	0.1		SE
28		ALUM			46				APD MI	0.013883	1	0.1		SE
28		ALUM			46				APD MI	0.048311	1	0.1		SE
60		APD MI	0.076667	1	0.1				FLOCCULAT	6	1	0.1		SE
35		APD MI	0.047687	1	0.1				FLOCCULAT	0.416847	1	0.1		SE
4		ALUM			33				APD MI	0.0046	1	0.1		SE
80		APD MI	0.068722	1	0.1				FLOCCULAT	2.3649	1	0.1		SE
20		ALUM			70				APD MI	0.016887	1	0.1		SE
21		CONTRACT T	0.14214	1	0.5				ALUM			3		FL
2		ALUM			5				APD MI	0.0104	1	0.1		SE
1		ALUM			25				APD MI	0.01125	1	0.1		SE
4		ALUM			12				APD MI	0.055516	1	0.1		SE
13		CONTRACT T	1.95	1	0.5				ALUM			104		FL
104		ALUM			115				APD MI	0.0715	1	0.1		SE
3		ALUM			20				APD MI	0.44	1	0.1		SE
7		APD MI	0.25	1	0.1				ALUM			25		SE
6		APD MI	0.00036	1	0.1				FLOCCULAT	0.56	1	0.1		SE
8		CONTRACT T	0.0963	1	0.5				ALUM			1		SE
3		ALUM			4				ALUM			1		SE
1		ALUM			7				APD MI	0.0215	1	0.1		SE

Process5	Volume	T50	T10	Dose	End	Process6	Volume	T50	T10	Dose	End	Process7	Volume	T50	T10	Dose	End	Process8	Volume	T50
ILTRATIO	0.291667	1	0.8			AMMONIA				0.68		SODIUM HYDROXIDE						CLEARWE	1.46667	1
TLING B	0.965	1	0.3			HLORINE				2.1		FILTRATIO	0.141667	1	0.8			HLORIN		
COULATI	3.0634	1	0.1			SETTLING B	4.3456	1	0.3			FILTRATIO	3.261	1	0.8			HLORIN		
TLING B	2.063333	1	0.3			FILTRATIO	0.3125	1	0.8			HLORINE						SODIUM HYDROXIDE		
ILTRATIO	0.2063	1	0.8			HLORINE						SODIUM HYDROXIDE								
ILTRATIO	0.78125	1	0.8			HLORINE				3		AMMONIA						CLEARWE	1.0417	1
TLING B	51.36	1	0.3			HLORINE				1.6		FILTRATIO	4.2156	1	0.8			SODIUM HYDROXIDE		
TLING B	35.9638	1	0.3			HLORINE				1.4		FILTRATIO	2.7428	1	0.8			HLORIN		
TLING B	9.5228	1	0.3			HLORINE				1.3		FILTRATIO	0.912	1	0.8			AMMONIA		
TLING B	9.5228	1	0.3			HLORINE				0.15		FILTRATIO	1.427	1	0.8			AMMONIA		
TLING B	39.0168	1	0.3			HLORINE				1.8		FILTRATIO	3.034	1	0.8			AMMONIA		
TLING B	22.6613	1	0.3			HLORINE				0.69		FILTRATIO	2.1119	1	0.8			HLORIN		
ALUM				50		APID MI	0.0125	1	0.1			FLOCCULAT	0.56	1	0.1			SETTLING B	2.4	1
TLING B	5.17839	1	0.3			HLORINE				1		FILTRATIO	0.8617	1	0.8			AMMONI		
ILTRATIO	0.1656	1	0.8			HLORINE				0.35		SODIUM HYDROXIDE						AMMONI		
TLING B	2.8742	1	0.3			HLORINE				1.2		FILTRATIO	0.3151	1	0.8			AMMONIA		
APID MI	0.0125	1	0.1			FLOCCULATI	0.875	1	0.1			SETTLING B	5.26	1	0.3			OZONE		
ALUM				72.5		APID MI	0.0024	1	0.1			FLOCCULATI	0.341	1	0.1			SETTLING B	0.825	1
ILTRATIO	0.681	1	0.8			HLORINE				2.5		SODIUM HYDROXIDE								
TLING B	3	1	0.3			FILTRATIO	0.46675	1	0.8			HLORINE						SODIUM HYDROXIDE		
TLING B	4.513869	1	0.3			FILTRATIO	0.871083	1	0.8			HLORINE						CLEARWE	2.706333	1
TLING B	0.694444	1	0.3			FILTRATIO	0.104167	1	0.8			HLORINE						CLEARWE	0.416667	1
TLING B	0.277778	1	0.3			FILTRATIO	0.041667	1	0.8			HLORINE						CLEARWE	0.166667	1
TLING B	0.972222	1	0.3			FILTRATIO	0.146833	1	0.8			HLORINE						CLEARWE	0.583333	1
ILTRATIO	0.125	1	0.8			HLORINE				1.5		SODIUM HYDROXIDE						CLEARWE	0.01	1
ILTRATIO	0.3125	1	0.8			HLORINE				2		PERMANGANATE						CLEARWE	1.25	1
TLING B	0.2025	1	0.3			FILTRATIO	0.03375	1	0.8			HLORINE						CLEARWE	0.136	1
ILTRATIO	0.78	1	0.8			HLORINE				5		AMMONIA						CONTACT T	0.8109	1
TLING B	0.75	1	0.3			HLORINE				0.8		FILTRATIO	0.125	1	0.8			HLORIN		
COULATI	0.694444	1	0.1			FILTRATIO	0.14982	1	0.8			HLORINE						AMMONIA		
TLING B	3.142	1	0.3			FILTRATIO	0.4679	1	0.8			HLORINE						SODIUM HYDROXIDE		
TLING B	4.8	1	0.3			HLORINE				2		FILTRATIO	4.73	1	0.8			HLORINE		
TLING B	4.922	1	0.3			HLORINE				1		AMMONIA						FILTRATIO	0.116	1
COULATI	3.41	1	0.1			HLORINE				1		FILTRATIO	6.25	1	0.8			HLORINE		
ILTRATIO	0.78	1	0.8			HLORINE				3.1		AMMONIA						CLEARWE	0.75	1
TLING B	5.4	1	0.3			HLORINE				1.3		FILTRATIO	0.41	1	0.8			AMMONIA		
TLING B	7.7	1	0.3			HLORINE				1.2		FILTRATIO	0.66	1	0.8			AMMONIA		
HLORINE				4		FILTRATIO	0.15	1	0.8			HLORINE						AMMONIA		
APID MI	0.000315	1	0.1			FLOCCULATI	1.226	1	0.1			SETTLING B	1.2542	1	0.3			FILTRATIO	0.36327	1
TLING B	1.220736	1	0.3			FILTRATIO	0.1772	1	0.8			HLORINE						AMMONIA		
TLING B	3.2	1	0.3			FILTRATIO	0.239	1	0.8			HLORINE						SODIUM HYDROXIDE		

916 736 3714: #13/22

Y

[illegible]

ALLIUM

9- 3-98 ; 3:21PM ; MALCOLM PIRNIE, PHO→

916 736 3714;#14/22

[illegible]



8-3-88 ; 3:21PM ; MALCOLM PIRNIE, PHO-

916 736 3714;#15/22

3:21 PM

Processing

Time	End	Process	Volume	T10	Dose	End	Strain
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0.5	CLEARW	50	1	0.5	
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**PEAK FLOW INPUT FILE**

16

D - 0 3 5 8 6 3

DWR Input File :

Filename here

Plant #	Influent	AveFlow	Peak Flow	pH	Temp	LowTemp	TOC	UV	Br	Alk	Ca	Hard	NH3	NTU	Gardis	SWFlag	End	Process1
1		22.4	22.4	7.5	17.2	10	3	0.1	0.1	50	100	120	0.01	14	1	TRUE		ALUM
2		13.6	13.6	6.8	19.2	10	3	0.1	0.1	58	40	120	0.01	3.7	1	TRUE		CHLORINE
3		28	28	7.5	16	10	3	0.1	0.1	70	100	120	0.01	10	1	TRUE		OZONE
4		30	30	8	16	10	3	0.1	0.1	90	100	170	0.01	2	1	TRUE		OZONE
5		25	25	8	16	10	3	0.1	0.1	90	100	170	0.01	2	1	TRUE		ALUM
6		75	75	8	17	10	3	0.1	0.1	80	70	70	0.01	4	1	TRUE		ALUM
7		750	750	7.81	14.3	10	3	0.1	0.1	97	110	179	0.01	0.72	1	TRUE		CHLORINE
8		46.71	46.71	8.19	21.2	10	3	0.1	0.1	133	156	258	0.01	2.01	1	TRUE		CHLORINE
9		18.688	18.688	8.33	22.9	10	3	0.1	0.1	121	157	260	0.01	2.28	1	TRUE		CHLORINE
10		21.686	21.686	8.32	23.8	10	3	0.1	0.1	119	156	259	0.01	1.96	1	TRUE		CHLORINE
11		39.06	39.06	8.2	20.9	10	3	0.1	0.1	109	153	254	0.01	2.77	1	TRUE		CHLORINE
12		49.5	49.5	8.03	19	10	3	0.1	0.1	78	50	108	0.01	6.31	1	TRUE		CHLORINE
13		20	20	7.8	16	10	3	0.1	0.1	90	100	170	0.01	36	1	TRUE		OZONE
14		5	5	7.8	17.7	10	3	0.1	0.1	82	60	108	0.01	2.8	1	TRUE		CHLORINE
15		48	48	7.8	17.4	10	3	0.1	0.1	77	56	102	0.01	4.5	1	TRUE		ALUM
16		38	38	8	18.2	10	3	0.1	0.1	78	57	98	0.01	7.7	1	TRUE		CHLORINE
17		16.8	16.8	8.1	18.4	10	3	0.1	0.1	117	53.2	125	0.01	17.3	1	TRUE		CHLORINE
18		7.5	7.5	7.71	19	10	3	0.1	0.1	84	46	97	0.01	39	1	TRUE		SODIUM HYDROXIDE
19		2.018	2.016	7.25	15	10	3	0.1	0.1	80	25	70	0.01	100	1	TRUE		ALUM
20		2.25	2.25	8.5	19	10	3	0.1	0.1	120	120	140	0.01	6	1	TRUE		PERMANGANATE
21		65	65	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5	1	TRUE		CHLORINE
22		10	10	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5	1	TRUE		CHLORINE
23		4	4	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5	1	TRUE		CHLORINE
24		14	14	8.1	15	10	3	0.1	0.1	75	15	75	0.01	5	1	TRUE		CHLORINE
25		12	12	7.3	15	10	3	0.1	0.1	97	18	76	0.01	40	1	TRUE		ALUM
26		30	30	7.8	21	10	3	0.1	0.1	50	100	120	0.01	10	1	TRUE		ALUM
27		3.24	3.24	7.79	15.8	10	3	0.1	0.1	75	50	94	0.01	7.93	1	TRUE		CHLORINE
28		43	43	8.3	18.5	10	3	0.1	0.1	60	40	90	0.01	10	1	TRUE		ALUM
29		12	12	8	18	10	3	0.1	0.1	80	100	120	0.01	5	1	TRUE		SODIUM HYDROXIDE
30		50	50	7.8	22	10	3	0.1	0.1	109	42	183	0.01	2.5	1	TRUE		OZONE
31		20	20	8.1	18.5	10	3	0.1	0.1	120	50	170	0.01	8	1	TRUE		CHLORINE
32		22.5	22.5	7.75	20.5	10	3	0.1	0.1	117	129	220	0.01	7	1	TRUE		CHLORINE
33		8	8	8.2	19.9	10	3	0.1	0.1	115	276	276	0.01	2	1	TRUE		CHLORINE
34		186	186	8.2	16	10	3	0.1	0.1	120	60	90	0.01	2.7	1	TRUE		OZONE
35		4.25	4.25	8.27	20	10	3	0.1	0.1	101	135	224	0.01	2.6	1	TRUE		CHLORINE
36		12	12	8.1	20	10	3	0.1	0.1	120	145	225	0.01	2	1	TRUE		CHLORINE
37		14	14	8.2	20	10	3	0.1	0.1	125	175	280	0.01	2	1	TRUE		ALUM
38		4	4	7.9	20	10	3	0.1	0.1	155	125	197	0.01	3	1	TRUE		ALUM
39		15	15	7.87	25	10	3	0.1	0.1	157	144	264	0.01	12.3	1	TRUE		CHLORINE
40		25	25	7.8	15	10	3	0.1	0.1	70	19	83	0.01	3	1	TRUE		CHLORINE
41		68	68	8.05	17.8	10	3	0.1	0.1	68	20	93	0.01	3	1	TRUE		CHLORINE

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Volume	ISO	TI0	Dose	End	Process2	Volume	ISO	TI0	Dose	End	Process3	Volume	ISO	TI0	Dose	End	Process4	Volume	ISO	TI0
			31		RAPID MIX	0.038389	1	0.1			CHLORINE						SETTLING BASIN	1.75	1	0.3
			2.1		ALUM				35.8		RAPID MIX	0.018869	1	0.1			FLOCCULATION	0.18869	1	0.1
			2.5		CONTACT TANK	0.4824	1	0.5			ALUM				20		RAPID MIX	0.0125	1	0.1
			1.5		CONTACT TANK	0.0625	1	0.5			ALUM				0.75		RAPID MIX	0.020833	1	0.1
			2		RAPID MIX	0.0104	1	0.1			FLOCCULATION	0.6844	1	0.1			SETTLING BASIN	2	1	0.3
			40		RAPID MIX	0.1041867	1	0.1			FLOCCULATION	1.04	1	0.1			SETTLING BASIN	3.36	1	0.3
			1.9		ALUM				2.7		RAPID MIX	0.1722	1	0.1			FLOCCULATION	12.824	1	0.1
			2.2		ALUM				4.1		RAPID MIX	0.2118	1	0.1			FLOCCULATION	7.946	1	0.1
			3.5		ALUM				5.6		RAPID MIX	0.0847	1	0.1			FLOCCULATION	2.488	1	0.1
			3.5		ALUM				5.3		RAPID MIX	0.0722	1	0.1			FLOCCULATION	3.573	1	0.1
			2.8		ALUM				3.8		RAPID MIX	0.1757	1	0.1			FLOCCULATION	7.85	1	0.1
			2.8		ALUM				4.6		RAPID MIX	0.0229	1	0.1			FLOCCULATION	4.799	1	0.1
			1.5		CONTACT TANK	0.10773	1	0.5			OZONE				0.5		CONTACT TANK	0.10773	1	0.5
			2		ALUM				32		RAPID MIX	0.0347	1	0.1			FLOCCULATION	1.6157	1	0.1
			35		RAPID MIX	0.0278	1	0.1			SETTLING BASIN	8.2	1	0.3			CHLORINE			
			2.5		ALUM				30		RAPID MIX	0.0139	1	0.1			FLOCCULATION	0.3147	1	0.1
			1.1		OZONE				0.6		CONTACT TANK	0.075	1	0.5			ALUM			
			3.5		CHLORINE				1.5		OZONE				15		CONTACT TANK	0.0359	1	0.5
			80		RAPID MIX	0.0014	1	0.1			FLOCCULATION	0.0008	1	0.1			SETTLING BASIN	0.048	1	0.3
			1.5		ALUM				30		RAPID MIX	0.0825	1	0.1			FLOCCULATION	3	1	0.1
			2.8		ALUM				46		RAPID MIX	0.225884	1	0.1			FLOCCULATION	1.354167	1	0.1
			2.8		ALUM				48		RAPID MIX	0.034722	1	0.1			FLOCCULATION	0.206333	1	0.1
			2.8		ALUM				48		RAPID MIX	0.013869	1	0.1			FLOCCULATION	0.083333	1	0.1
			2.8		ALUM				46		RAPID MIX	0.048611	1	0.1			FLOCCULATION	0.291667	1	0.1
			80		RAPID MIX	0.0186867	1	0.1			FLOCCULATION	6	1	0.1			SETTLING BASIN	6	1	0.3
			35		RAPID MIX	0.0416867	1	0.1			RAPID MIX	0.0645	1	0.1			FLOCCULATION	0.045	1	0.1
			4		ALUM				33		FLOCCULATION	2.3539	1	0.1			SETTLING BASIN	9.7321	1	0.3
			50		RAPID MIX	0.0587222	1	0.1			FLOCCULATION	0.016867	1	0.1			FLOCCULATION	0.168667	1	0.1
			20		ALUM				70		RAPID MIX						RAPID MIX	0.0208	1	0.1
			2.1		CONTACT TANK	0.14214	1	0.5			ALUM				3		FLOCCULATION	1.053	1	0.1
			2		ALUM				5		RAPID MIX	0.0104	1	0.1			FLOCCULATION	0.3112	1	0.1
			1		ALUM				28		RAPID MIX	0.03125	1	0.1			FLOCCULATION	1.284	1	0.1
			4		ALUM				12		RAPID MIX	0.055555	1	0.1			RAPID MIX	0.1	1	0.1
			1.3		CONTACT TANK	1.95	1	0.5			ALUM				1.04		FLOCCULATION	0.2571	1	0.1
			1.04		ALUM				11.5		RAPID MIX	0.0116	1	0.1			FLOCCULATION	2	1	0.1
			3		ALUM				20		RAPID MIX	0.44	1	0.1			FLOCCULATION	2.9	1	0.1
			7		RAPID MIX	0.025	1	0.1			CHLORINE				2.5		SETTLING BASIN	0.3	1	0.3
			5		RAPID MIX	0.00036	1	0.1			FLOCCULATION	0.56	1	0.1			ALUM			
			8		CONTACT TANK	0.0563	1	0.5			ALUMINA				1		FLOCCULATION	0.3	1	0.1
			3		ALUM				4		RAPID MIX	0.00048	1	0.1			FLOCCULATION	0.3	1	0.1
			1		ALUM				7		RAPID MIX	0.0215	1	0.1			FLOCCULATION	0.8	1	0.1

Dose	End	Process5	Volume	T50	T10	Dose	End	Process6	Volume	T50	T10	Dose	End	Process7	Volume	T50	T10
		FILTRATION	0.2916887	1	0.8			AMMONIA				0.68		SODIUM HYDROXIDE			
		SETTLING BASIN	0.965	1	0.3			CHLORINE				2.1		FILTRATION	0.14167	1	0.8
		FLOCCULATION	3.0834	1	0.1			SETTLING BASIN	4.3856	1	0.3			FILTRATION	3.261	1	0.8
		SETTLING BASIN	2.0833333	1	0.3			FILTRATION	0.3125	1	0.8			CHLORINE			
		FILTRATION	0.2083	1	0.8			CHLORINE				3		SODIUM HYDROXIDE			
		FILTRATION	0.78125	1	0.8			CHLORINE				3		AMMONIA			
		SETTLING BASIN	51.36	1	0.3			CHLORINE				1.6		FILTRATION	4.2156	1	0.8
		SETTLING BASIN	35.9638	1	0.3			CHLORINE				1.4		FILTRATION	2.7428	1	0.8
		SETTLING BASIN	9.5228	1	0.3			CHLORINE				1.3		FILTRATION	0.912	1	0.8
		SETTLING BASIN	9.5228	1	0.3			CHLORINE				0.15		FILTRATION	1.427	1	0.8
		SETTLING BASIN	39.0166	1	0.3			CHLORINE				1.8		FILTRATION	3.034	1	0.8
		SETTLING BASIN	22.6913	1	0.3			CHLORINE				0.89		FILTRATION	2.1119	1	0.8
		ALUM				50		RAPID MIX	0.0125	1	0.1			FLOCCULATION	0.56	1	0.1
		SETTLING BASIN	5.17636	1	0.3			CHLORINE				1		FILTRATION	0.8817	1	0.8
1.8		FILTRATION	0.1956	1	0.8			CHLORINE				0.35		SODIUM HYDROXIDE			
		SETTLING BASIN	2.8742	1	0.3			CHLORINE				1.2		FILTRATION	0.3151	1	0.8
45		RAPID MIX	0.0125	1	0.1			FLOCCULATION	0.875	1	0.1			SETTLING BASIN	5.25	1	0.3
		ALUM				72.5		RAPID MIX	0.0024	1	0.1			FLOCCULATION	0.341	1	0.1
		FILTRATION	0.021	1	0.8			CHLORINE				2.5		SODIUM HYDROXIDE			
		SETTLING BASIN	3	1	0.3			FILTRATION	0.48875	1	0.8			CHLORINE			
		SETTLING BASIN	4.5136889	1	0.3			FILTRATION	0.677083333	1	0.8			CHLORINE			
		SETTLING BASIN	0.6944444	1	0.3			FILTRATION	0.104166667	1	0.8			CHLORINE			
		SETTLING BASIN	0.2777778	1	0.3			FILTRATION	0.041666667	1	0.8			CHLORINE			
		SETTLING BASIN	0.9722222	1	0.3			FILTRATION	0.145833333	1	0.8			CHLORINE			
		FILTRATION	0.125	1	0.8			CHLORINE				1.5		SODIUM HYDROXIDE			
		FILTRATION	0.3125	1	0.8			CHLORINE				2		PERMANGANATE			
		SETTLING BASIN	0.2025	1	0.3			FILTRATION	0.03375	1	0.8			CHLORINE			
		FILTRATION	0.79	1	0.8			CHLORINE				5		AMMONIA			
		SETTLING BASIN	0.75	1	0.3			CHLORINE				0.8		FILTRATION	0.125	1	0.8
		FLOCCULATION	0.6944444	1	0.1			FILTRATION	0.14962	1	0.8			CHLORINE			
		SETTLING BASIN	3.142	1	0.3			FILTRATION	0.4978	1	0.8			CHLORINE			
		SETTLING BASIN	4.8	1	0.3			CHLORINE				2		FILTRATION	4.73	1	0.8
		SETTLING BASIN	4.922	1	0.3			CHLORINE				1		AMMONIA			
		FLOCCULATION	3.41	1	0.1			CHLORINE				1		FILTRATION	6.25	1	0.8
		FILTRATION	0.79	1	0.8			CHLORINE				3.1		AMMONIA			
		SETTLING BASIN	5.4	1	0.3			CHLORINE				1.3		FILTRATION	0.41	1	0.8
		SETTLING BASIN	7.7	1	0.3			CHLORINE				1.2		FILTRATION	0.58	1	0.8
		CHLORINE				4		FILTRATION	0.15	1	0.8			CHLORINE			
10		RAPID MIX	0.000015	1	0.1			FLOCCULATION	1.236	1	0.1			SETTLING BASIN	1.2542	1	0.3
		SETTLING BASIN	1.220736	1	0.3			FILTRATION	0.17772	1	0.8			CHLORINE			
		SETTLING BASIN	3.2	1	0.3			FILTRATION	0.239	1	0.8			CHLORINE			

Dose	End	Process	Volume	150	110	Dose	End	Process	Volume	150	110	Dose	End	Process	Volume	150	110	Dose	End
17		CLEARWELL	1.1667	1	0.5	1.2		AMMONIA				0.6		SODIUM HYDROXIDE				18	
		CHLORINE				1.5		AMMONIA				0.5		SODIUM HYDROXIDE				15	
2		SODIUM HYDROXIDE				2		CLEARWELL	1.25	1	0.5								
2		CLEARWELL	1.0417	1	0.5														
0.4		SODIUM HYDROXIDE				20		CLEARWELL	10	1	0.5								
		CHLORINE				2		AMMONIA				0.34		SODIUM HYDROXIDE				4.9	
		AMMONIA				0.34		SODIUM HYDROXIDE				2		CLEARWELL	24.9	1	0.5		
		AMMONIA				0.38		CHLORINE				0.25		SODIUM HYDROXIDE				2	
		AMMONIA				0.45		SODIUM HYDROXIDE				2		CLEARWELL	110.93	1	0.5		
		AMMONIA				0.38		SODIUM HYDROXIDE				2.2		CLEARWELL	50	1	0.5		
		CHLORINE				0.72		AMMONIA				0.41		SODIUM HYDROXIDE				7.1	
		SETTLING BASIN	2.4	1	0.3			FILTRATION	0.3351	1	0.8			OZONE				0.3	
		AMMONIA				0.35		SODIUM HYDROXIDE				5		CLEARWELL	10	1	0.5		
10		AMMONIA				0.3		CLEARWELL	1.5	1	0.5								
		AMMONIA				0.3		SODIUM HYDROXIDE				5.8		CLEARWELL	3	1	0.5		
		OZONE				0.9		CONTACT TANK	0.35	1	0.5			FILTRATION	0.4375	1	0.8		
		SETTLING BASIN	0.625	1	0.3			FILTRATION	0.066	1	0.8			SODIUM HYDROXIDE				4	
15																			
5		SODIUM HYDROXIDE				5		CLEARWELL	1.875	1	0.5								
2.8		CLEARWELL	2.70833	1	0.5														
2.8		CLEARWELL	0.41667	1	0.5														
2.8		CLEARWELL	0.16667	1	0.5														
2.8		CLEARWELL	0.83333	1	0.5														
2.4		CLEARWELL	0.01	1	0.5														
0.65		CLEARWELL	1.25	1	0.5														
4		CLEARWELL	0.135	1	0.5														
3.5		CONTACT TANK	0.8109	1	0.5			SODIUM HYDROXIDE				50		CLEARWELL	1.79167	1	0.5		
		CHLORINE				1.1		SODIUM HYDROXIDE				9		CONTACT TANK	0.26	1	0.5		
1.7		AMMONIA				0.37		SODIUM HYDROXIDE				10		CLEARWELL	8.109	1	0.5		
1.5		SODIUM HYDROXIDE				9		CLEARWELL	16	1	0.5								
		CHLORINE				1.5		CLEARWELL	5.5	1	0.5								
0.5		FILTRATION	0.116	1	0.8			SODIUM HYDROXIDE				3		CLEARWELL	5.4	1	0.5		
		CHLORINE				2		CLEARWELL	25	1	0.5								
1.08		CLEARWELL	0.75	1	0.5														
		AMMONIA				0.465		CLEARWELL	42	1	0.5			SODIUM HYDROXIDE				12	
		AMMONIA				0.45		CLEARWELL	52	1	0.5								
0.4		AMMONIA				0.631		CLEARWELL	15	1	0.5								
		FILTRATION	0.30633	1	0.8			SODIUM HYDROXIDE				8		CHLORINE				0.5	
1.5		AMMONIA				0.6		SODIUM HYDROXIDE				4		CLEARWELL	16	1	0.5		
1		SODIUM HYDROXIDE				3		CLEARWELL	8	1	0.5			AMMONIA				0.22	

Process11	Volume	T50	T10	Dose	End	Process12	Volume	T50	T10	Dose	End	Process13	Volume	T50	T10	Dose	End	Process14	Volume	T50	T10
CONTACT TANK	0.073	1	0.5			CLEARWELL	20	1	0.5												
CLEARWELL	50	1	0.5																		
CLEARWELL	110.93	1	0.5																		
CLEARWELL	50	1	0.5																		
CONTACT TANK	0.0808	1	0.5			OZONE				0.1		CONTACT TANK	0.0808	1	0.5						
SODIUM HYDROXIDE																					
CHLORINE				9		CHLORINE				1.5		CLEARWELL	0.3125	1	0.5						
				1.5		CLEARWELL						CLEARWELL	0.165	1	0.5						
CLEARWELL	5	1	0.5																		
CLEARWELL	10	1	0.5																		

CHLORINE

Dose	End	Process	15	Volume	150	T10	Dose	End	Process	16	Volume	150	T10	Dose	End	Strain
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CONTACT TANK	0.8268	1	0.5
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CLEARWELL	50	1	0.5
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# CONTRA COSTA WATER DISTRICT

## TELEFAX

**FROM:** Contra Costa Water District  
**Water Quality Section**  
 125-J Mason Circle  
 Concord, CA 94520

**Date:** 9/4/98

**Total Pages:** 2  
 (Including cover sheet)

**FAX #:** (925) 688-8274

**Phone:** (925) 688-8127

**Contact:** Larry J. McCollum, WQ Superintendent  
 \*\*\*\*\*

Rick,  
 Richard Denton sent you some info on the canal drainage issue for the bromide panel. The following is in response to the request for information about the treatment plants utilizing the Delta source. All the the below use water from the Contra Costa Canal, in whole or in part, for their raw water supply.

**Randall-Bold treatment process summary**  
 40 mgd direct filtration plant, currently operated at an average flow rate of about 5 mgd.

**Processes:**

Pre-ozonation (ave. dose 2.5 mg/L) No CT credit from pre-oz.  
 Coagulation: alum (ave. dose 30 mg/l.)  
                   cationic polymer (ave. dose 1.0 mg/L)  
                   nonionic polymer (ave. dose 0.1 mg/L)

**Flocculation**

Filtration: 80" GAC/40" sand  
 Post-ozonation (ave. dose 0.5 mg/L) All CT credit from post-oz.  
 Chloramination (1.5 mg/L residual in plant effluent) 4:1  
 chlorine/ammonia  
 pH adjustment to 8.9 - 9.0

Typical raw water pH = 7.7

Typical post-ozonation water pH = 7.0

Pre-ozone and post-ozone contactor detention time @ 5 mgd = 22.5 min.

**Bollman treatment process summary**

75 mgd conventional filtration plant, currently operated at an average flow rate of about 32 mgd.

**Processes:**

Pre-oxidation: potassium permanganate (ave. dose 0.7 mg/L)  
 Coagulation: alum (ave. dose 30 mg/L)  
                   cationic polymer (ave. dose 1.6 mg/L)  
                   nonionic polymer (ave. dose 0.01 mg/L)

**Flocculation**

**Sedimentation**

Filtration: 44" GAC/5" sand

Primary Disinfection: free chlorine contact time 9 - 45 minutes with 1.5 mg/L residual  
 pH adjustment to 8.9 - 9.0  
 Chloramination (1.5 mg/L residual in plant effluent.) 4:1 chlorine/ammonia

Typical raw water pH = 7.7  
 Typical settled water pH = 7.0

Intermediate ozone facilities are currently under construction at Bollman, which will provide a max. ozone dose of 3 mg/L. Detention time through the ozone contactors will be 10 min. at 75 mgd.

The following table was extracted from our Sanitary Survey.

**Table 2-8 Treatment Plant Configurations within CCWD Raw Service Area**

Plant	Preoxidant	Coagulation	Floc	Sed	Intermediate Ozone	Filtration	Disinfection	Capacity	Estimated Population Served
Bollman	KMnO <sub>4</sub> or Chlorine	Alum/Poly	yes	yes	under construction	GAC	Chloramines	75 MGD	185,000
R-B	Ozone	Alum/Poly	yes	no	no	Deep GAC	Ozone -- Chloramines	40 MGD	21,000
Antioch	Chlorine	Alum	yes	yes	no	GAC	Chloramines	28 MGD	76,000
Pittsburg	Chloramines	Alum/Poly	yes	yes	no	GAC	Chloramines	36 MGD	50,000
Ca Cities	KMnO <sub>4</sub>	Alum/Poly	yes	yes	no	Anthracite	Chlorine	3.8 MGD	15,000
Martinez	Ozone	Alum	yes	yes	yes	Anthracite	Chloramines	10 MGD	30,000

Hope this helps with the process. Richard should be in attendance at the meeting on Tues and Weds. It is my hope that I will also be able to attend.

\*\*\*\*\*

TO:

**Rick Woodard  
 Chief, WQ Prog  
 CALFED**

FAX

**(916) 653-5699**

**Water Quality Degradation  
From Point of Delta Diversion  
to Treatment Plant Intakes**

**M e m o r a n d u m**

Date : September 3, 1998

To : Rick Woodard, Manager  
Water Quality ProgramFrom : Larry Joyce, Chief  
Water Quality Section  
Department of Water Resources

Subject: Source Water Degradation in Transit

This memo is in response to your August 26 memo on source water quality degradation in transit.

While it is not possible to analyze all the available information on all the topics you identified in the timeframe allotted, significant insights can be provided from prior analysis of SWP water quality. The current status and understanding of this issue is summarized below.

**The Delta**

Water quality in the Sacramento - San Joaquin Delta is the single most significant factor that dictates the quality of water delivered by the SWP. In very gross terms when the water supply in the Delta is high the quality of SWP water will remain good throughout the year and good quality water will be placed in storage for the future. When water supply in the Delta is limited the quality of the exported water tends to be relatively lower. For some parameters there are changes in SWP water quality between the Delta and the final delivery point. The magnitude of this change is usually small relative to the seasonal and annual variability seen in the Delta.

**Factors Influencing Water Quality in the California Aqueduct**

The California Aqueduct conveys Delta water directly to O'Neill Forebay through Check 12. There is little detectable change in water quality between the Delta and Check 12. CVP water enters the Forebay from the Delta-Mendota Canal via the CVP O'Neill Pump/generation Plant. From the Forebay, the combined water is either stored in the San Luis Reservoir or released downstream through Check 13 into the San Luis Canal, or released back into the Delta-Mendota Canal. CVP Delta-Mendota Canal flow usually enters O'Neill Forebay during the fall, winter and spring months when San Luis Reservoir is normally filling. San Luis Reservoir generally releases water into O'Neill Forebay in late spring and summer to coincide with the agricultural irrigation season. During these months, California Aqueduct inflows pumped from the Delta generally pass directly through O'Neill Forebay into the San Luis Canal without diversions into San Luis Reservoir. Water entering O'Neill

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SURNAME

*Larry Joyce*

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Forebay from the CVP's Delta-Mendota Canal typically has a slightly higher mineral content than SWP water because a greater proportion of San Joaquin River water is pumped from the Delta.

Factors influencing water quality in the San Luis Canal and San Joaquin Reach are generally seasonal, intermittent and related to water year conditions. Though water quality between Check 13 and 41 is primarily determined by the quality of Delta export water and San Luis Reservoir. However, floodwater inflow from several sources along the San Luis Canal can influence water quality. The San Luis Canal (Check 13-21) was built with drain inlets, and pump pads that may allow floodwater to enter and degrade SWP water quality. In the San Joaquin Reach, the Kern River Intertie and the Cross Valley Canal can be operated to allow floodwater or exchange water to enter the aqueduct. During periods of drought, cooperative water sharing programs have allowed groundwater supplies to be pumped into the aqueduct on an emergency basis. In the Southern Reservoirs water quality can change while in storage and can be influenced by runoff from local watersheds.

### **San Luis Canal**

The San Luis Canal (from Check 13 To Check 21), O'Neill Forebay, and San Luis Reservoir are joint-use facilities of the SWP and CVP. The San Luis canal has 61 drain inlets that convey floodwaters into the aqueduct. Floodwaters are accepted into the SLC when the capacity of bypasses (culverts and overchutes) and ponding areas are exceeded. Between 1973 to 1993 annual floodwater inflow ranged from 0 to 41,938 AF. When inflow occurs, floodwater usually composed less than 10 percent of SLC flows. The quality of the flood inflows into the San Luis Canal are influenced by the geochemistry of the 34 watersheds of the Diablo Range. Many contain ancient marine deposits that may contribute high levels of sulfate, chloride, magnesium and selenium. More localized serpentine formations may contribute asbestos. Years with large floodwater inflows are relatively rare events. Only four, of the 14 years between 1973 and 1995 with measurable inflow, accounted for more than 20,000 AF of inflow to the SLC, most other years inflow was less than 5,000 AF.

In years with above normal rainfall in the Diablo Range TDS, sulfate, hardness and boron increased between Check 13 and Check 21 due to the floodwater inflow. Although high levels of some metals, nutrients and organic chemicals have been detected in a few of the smaller watersheds, they did not significantly influence aqueduct water quality.

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Historically, most floodwater entered the aqueduct from five sources: Arroyo Passajero, Kern River Intertie, Salt, Cantua and Little Panoche Creeks. In 1986, modifications to the adjacent ponding area and changes in operation lessened Arroyo Passajero's inflow to the aqueduct. DWR and the U.S. Army Corps of Engineers are involved in a feasibility study to further control floodwater in the Arroyo Passajero watershed and for other sources in the Cantua stream group.

The Kern River Intertie and Cross Valley Canal can both be used to allow floodwater from the Sierra Mountains to enter. This source water is usually better than Aqueduct water quality.

### **Ground water Pump-in**

In response to drastic cutbacks in entitlement during 1991 and 1992, both CVP and SWP contractors entered into groundwater pump-in agreements for drought relief. Local water districts constructed temporary turn-in facilities to pump ground water into the California Aqueduct. The water was used immediate downstream, credited against water stored in San Luis, or used to "pay-back" deliveries made earlier in the year. Acceptance to the non-project groundwater pump-in was restricted to water of a quality that did not result in significant degradation of SWP water quality, as specified in the DWR Policy on Non-Project Groundwater Inflow. In spite of these restriction measurable impacts on SWP water quality were observed, primarily with respect to salinity. Pump-in program covered six years and inflow volumes ranged from 5,027 AF in 1990 to a high of 175,449 AF in 1991. Over 64 percent by volume entered the San Luis Canal and 32 percent entered the San Joaquin Reach of the SWP (Check 21 to Check 41). The program ended in 1995 with the end of the drought.

### **Salinity**

Salinity in the California Aqueduct can be influenced by a number of factors including evaporation, CVP operations at O Neill Forebay, floodwater inflow, ground water inflow and natural watershed inflow to the reservoirs. In both 1994, a dry year, and 1995, a wet year, minerals in general increased in the California aqueduct between Banks Pumping Plant and locations down stream. The observed increases were caused by several factors. In 1995 many salts, including Chloride, dissolved solids, sodium, hardness and sulfate, were slightly higher at Check 13 than Banks due in part to operations at O Neill but also because higher salinity water had been stored in San Luis Reservoir the year before. The greatest station-to-station

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increases in salinity in both 1994 and 1995 were between Checks 13 and 21 as a result of pump-in and floodwater inflow. The levels of specific conductance, total dissolved solids hardness and sulfate have been shown to increase measurably during periods of flood inflow and groundwater pump-in along the San Luis Canal.

Results of water quality monitoring for both pump-in and aqueduct indicate that most impacts to aqueduct water quality were localized with short duration. However, during drought years of 1991 and 1992, there was a noticeable increase in the proportion of sulfate at stations below Check 13 and a corresponding decrease in the proportion of chloride attributed to the influence of groundwater pump-ins. In some months high levels of arsenic, TDS, Sulfate, and specific conductance in pump-in water did increase downstream SLC Aqueduct values.

The salinity of the East Branch Reservoirs tends to follow the salinity in the California Aqueduct which is largely determined by Delta export condition with some short term impacts from events in transit. Water delivered on the West Branch is usually more saline with the long term average TDS at Castaic lake about 75 mg/l higher than at Devil Canyon. High salinity local runoff is the primary reason for increased salinity on the West Branch. Local inflow, in some year, can account for more than 40 percent of the inflow to Pyramid and Castaic Lakes.

### **Bromide**

Bromide in the SWP is primarily influenced by salinity intrusion in the Delta. Bromide levels in wet years can be less than half the level of dry years. Slight changes in bromide concentrations may be possible between Banks and Check 13 due to O'Neill operations. Mean annual bromide levels are relatively stable between stations from Check 13, Check 21 and Check 41. During 1991 and 92, bromide levels were highest between January and April. In 1994 and 1995, under a more varied export conditions, bromide values were highest in September in 1994 and April of 1995.

### **Total Suspended Solids**

Floodwater inflow is a significant cause of increased total suspended solids (and turbidity) in the California Aqueduct in some years. Sediment loading from floodwaters entering can be significant compared to that from the Delta. It has been estimated that in some months when there is high floodwater inflow as much as 20 percent of the TSS in the aqueduct is carried in by floodwater. Two of the larger drain inlets, Salt and Cantua Creek, exhibit mean TSS levels between 500 and

800 mg/L, with values recorded as high as 13,000 mg/L. Normal Aqueduct background TSS values ranging between 5 to 12 mg/L. The movement of sediment bed load and resuspension under higher aqueduct flows can sustain high TSS levels months after a flood event. In March and April 1995, 26,000 AF of runoff entered the SLC depositing 133 to 146 thousand cubic yards of sediment. TSS values at check 21 and 41 ranged from 173 to over 500 mg/l for the next 7 months, peaking in July, with high aqueduct flow rates.

### **Total Organic Carbon**

Annual average TOC levels in the California Aqueduct do not differ greatly from north to south during either wet or dry conditions. Maximum concentrations are also not appreciably different, however the timing of peak concentrations vary. For example during 1994, a dry year, annual mean TOC concentrations at Banks, Check 41 Devil Canyon and Castaic Lake ranged from 3.5 mg/l to 4.4 mg/l. Peak levels at those sites in 1994 were between 4.4 mg/l and 6.9 mg/l. During 1995, a wet year, mean annual TOC at Banks was 4.2 mg/l while all downstream locations had a mean value of 3.9 mg/l and peak values in 1995 ranged from 4.4 mg/l to 8.0 mg/l (at Banks). In contrast on the North Bay Aqueduct during 1994 the mean TOC was 4.5mg/l and maximum 5.5mg/l and in 1995 the mean was 10.1 and maximum 21.3.

The general the greatest factor influence on TOC in the California Aqueduct appears to be the concentration at the time of export from the Delta. Floodwater inflow in the San Luis Canal can contribute significant levels of TOC with some sources measured as high as 35 mg/l. Overall TOC levels in the SWP do not appear to be significantly affected by events in transit. This does not necessarily hold true for water held in storage where local watersheds and algal activity can influence TOC levels.

### **Nutrients**

Nutrients in the California Aqueduct have not been analyzed as extensively in the past as some of the parameters described above. Recent data for the years 1996 and 1997 show similar levels for total phosphorus and nitrate at both Banks and Check 4. Total Phosphorus at Banks for those years ranged from .08 mg/l to .20 mg/l and Check 41 ranged from .05 mg/l to a high of .30 mg/l. Total Phosphorus in Pyramid Lake appears to be in the same range with a maximum level of .27 mg/l. However, Castaic Lake was lower ranging from about .02 to .07 mg/l. In that two year period, nitrate at Banks ranged from 1 to 5 mg/l while check 41 went from a low of 1-7 mg/l. In general nitrate levels at all aqueduct sites tended to be higher in winter



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than summer. In San Luis the seasonal variability seems to be similar to Banks, but the maximum level measured was less than 4 mg/l. Nitrate levels at Devil Canyon and in the southern reservoirs tended to be more stable with lower concentrations than the aqueduct.

The trends describe above may not hold true for all years and water conditions. More data needs to be analyzed to determine if there are any real changes in nutrient levels as water move through the SWP. Detailed analysis is needed to understand the relationship of nutrients to biological activity in the reservoirs.

### **Pathogens**

DWR has participated in pathogen surveys since 1992 intended to characterize the pathogen levels in the SWP, specifically targeting Giardia and Cryptosporidium. The initial screening for these pathogens was a coordinated effort involving DWR, MWD and Kern Co Water Agency. This effort found low levels of pathogens throughout the SWP. Levels were slightly higher in the source water for the SWP (in the Delta, at Banks Pumping Plant and DMC) than in the southern reaches of the California Aqueduct. Subsequent monitoring has included work by MWD in the southern reservoirs, routine monitoring by O&M, and by the Coordinated Pathogen Monitoring Program. Results from these activities indicate that storm events can raise concentrations of pathogens both in the Delta and in the local watersheds of the southern reservoirs. The CPMP detected both pathogens more frequently in the wet season than dry season, with lower detection frequency and concentration in the southern reaches of the SWP.

While pathogen levels appear to decrease in transit, the quality of the data probably does not warrant such a conclusion. Interpretation of the results of pathogen monitoring has been hampered by interference from high levels of turbidity and organic material in the water and limitations of the sample collection and analytical methods.

### **Farm Bridges on the South Bay Aqueduct**

With respect to the farm bridges on the South Bay Aqueduct, Delta Field Division has refurbished seven of the eight bridges. The bridges have been lined with plywood and sealed so that water will run off the bridges rather than go through the planks into the aqueduct. Work on last bridge will be completed this fiscal year.

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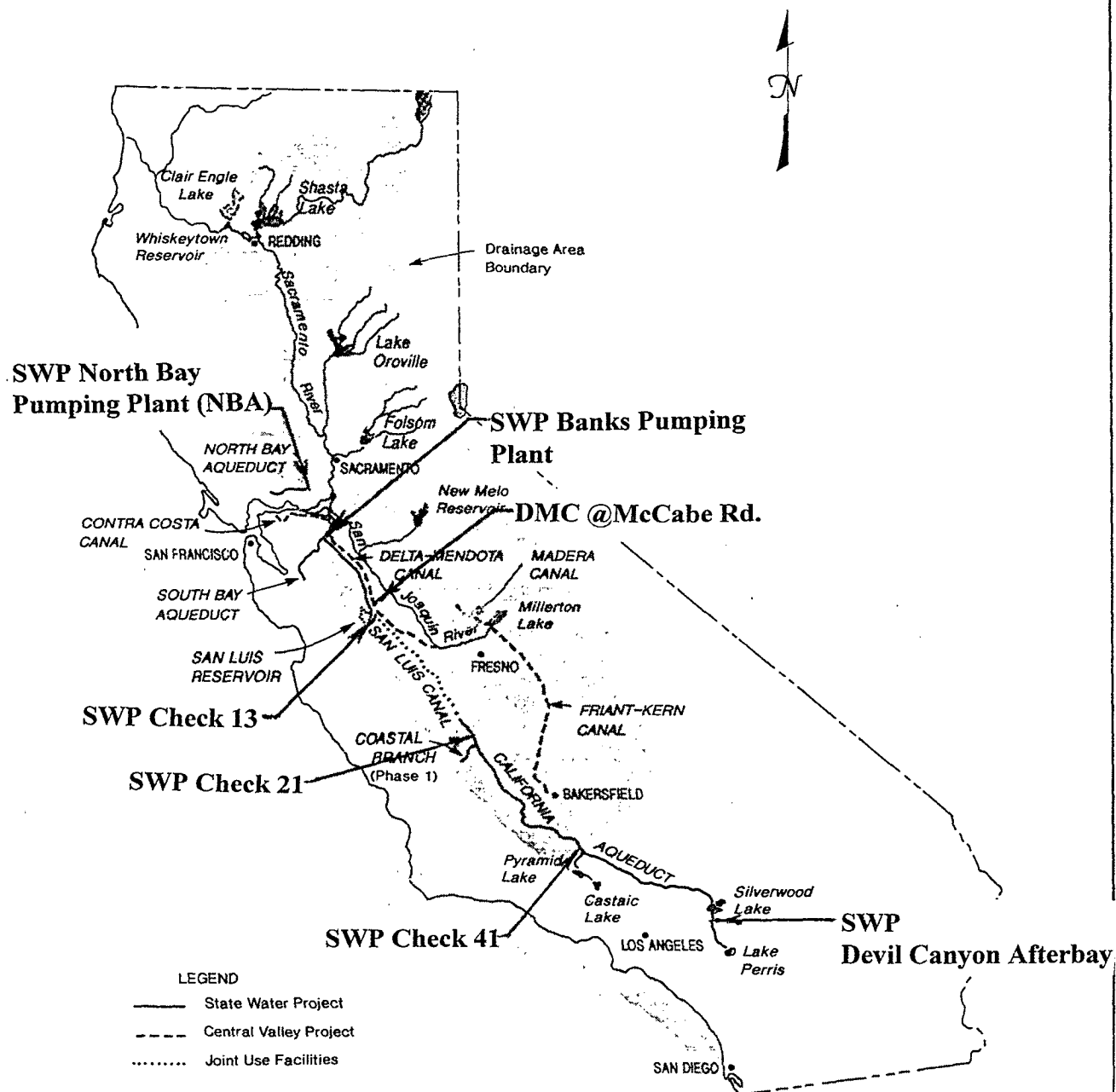
If you have any questions regarding the information provided, please call me at 653-7213.

cc: Dan Peterson/620  
Tom Glover/649  
Ed Huntley/605

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# Selected State Water Project Sampling Locations



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Major Features of State Water Project  
and Central Valley Project

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## Summary of State Water Project Bromide Data

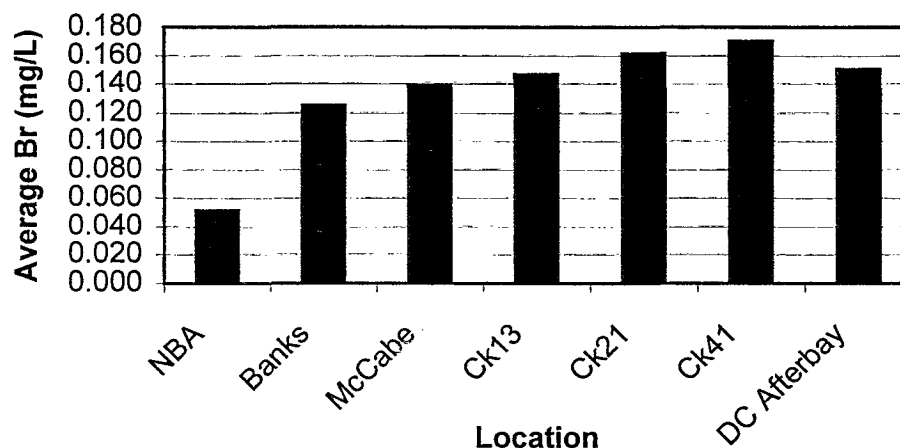
for the period January 1995 through March 1998

Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Bromide	0.010	0.051	0.200	0.033	37
Banks	Bromide	0.040	0.125	0.440	0.094	39
McCabe	Bromide	0.040	0.139	0.420	0.088	38
Ck13	Bromide	0.050	0.147	0.430	0.074	38
Ck21	Bromide	0.060	0.161	0.390	0.082	14
Ck41	Bromide	0.040	0.170	0.380	0.085	32
DC Afterbay	Bromide	0.080	0.150	0.280	0.044	34

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Location	Avg
NBA	0.051
Banks	0.125
McCabe	0.139
Ck13	0.147
Ck21	0.161
Ck41	0.170
DC Afterbay	0.150

### Bromide in the State Water Project



Note: According to data collected by Santa Clara Valley Water District from the end of the South Bay Aqueduct, bromide averaged 0.104 mg/L, with a Standard Deviation of 0.056 mg/L for the period March 1995 through August 1997.

Unpublished Data  
Subject to Revision

File: SWPDataSummary.XLS

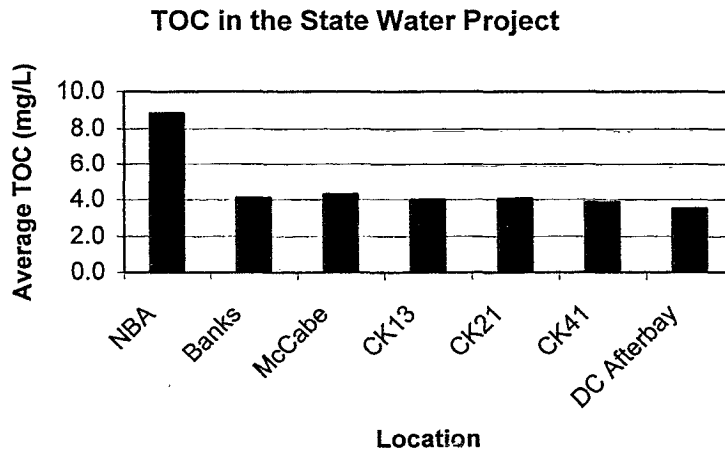
## Summary of State Water Project Total Organic Carbon Data

for the period January 1995 through March 1998

Location	Parameter	Min	Avg	Max	StDev	#Samples	Units
NBA	Carbon-Total Organic	4.0	8.9	21.0	4.8	38	mg/L
Banks	Carbon-Total Organic	3.0	4.1	10.0	1.7	39	mg/L
McCabe	Carbon-Total Organic	3.0	4.3	15.0	2.2	38	mg/L
CK13	Carbon-Total Organic	3.0	4.0	8.0	1.3	38	mg/L
CK21	Carbon-Total Organic	3.0	4.1	9.0	1.7	14	mg/L
CK41	Carbon-Total Organic	3.0	3.9	8.0	1.3	33	mg/L
DC Afterbay	Carbon-Total Organic	2.0	3.5	6.0	1.0	34	mg/L

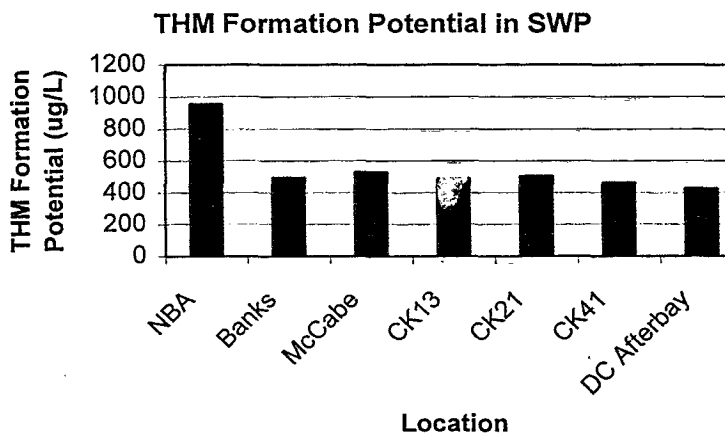
Location	Avg
NBA	8.9
Banks	4.1
McCabe	4.3
CK13	4.0
CK21	4.1
CK41	3.9
DC Afterbay	3.5

Unpublished Data  
Subject to Revision



Location	Parameter	Min	Avg	Max	StDev	#Samples	Units
NBA	THM Formation Potential	468	957	2011	474	37	ug/L
Banks	THM Formation Potential	283	498	1062	170	38	ug/L
McCabe	THM Formation Potential	304	532	1752	256	38	ug/L
CK13	THM Formation Potential	150	492	979	149	37	ug/L
CK21	THM Formation Potential	280	506	949	174	12	ug/L
CK41	THM Formation Potential	267	466	761	132	37	ug/L
DC Afterbay	THM Formation Potential	220	430	949	126	38	ug/L

Location	Avg
NBA	957
Banks	498
McCabe	532
CK13	492
CK21	506
CK41	466
DC Afterbay	430



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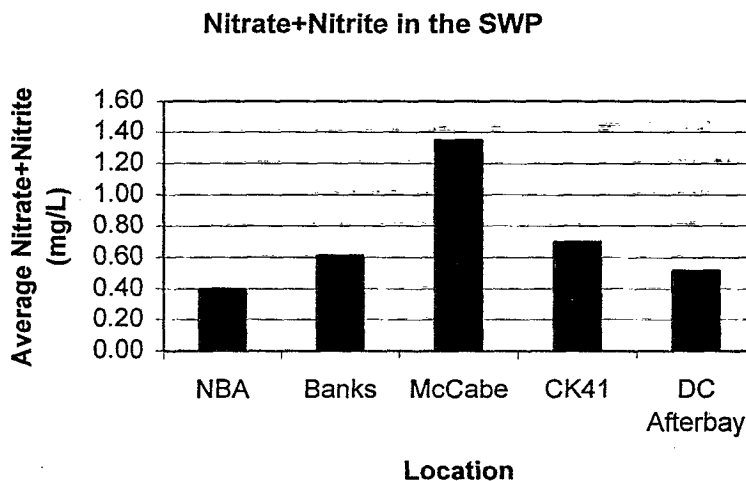
# Summary of State Water Project Nutrients Data

for the period January 1995 through March 1998

Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Nitrate + nitrite	0.02	0.40	3.50	0.56	38
Banks	Nitrate + nitrite	0.09	0.61	1.50	0.35	39
McCabe	Nitrate + nitrite	1.30	1.35	1.40	0.07	2
CK41	Nitrate + nitrite	0.14	0.70	1.70	0.42	38
DC Afterbay	Nitrate + nitrite	0.14	0.52	1.90	0.27	39

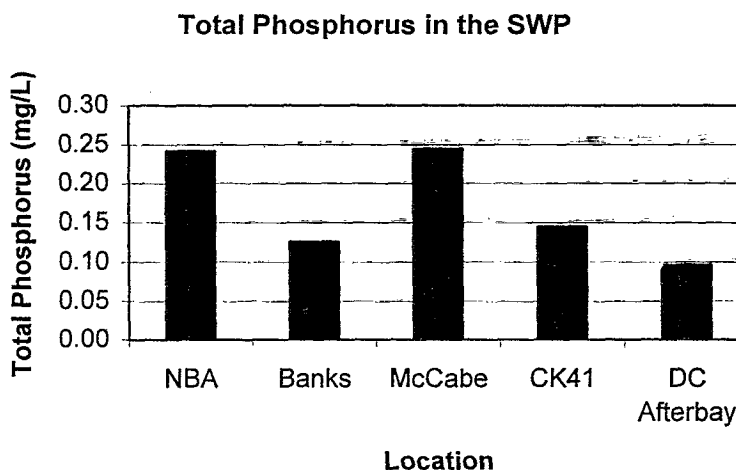
Location	Avg
NBA	0.40
Banks	0.61
McCabe	1.35
CK41	0.70
DC Afterbay	0.52

Unpublished Data  
Subject to Revision



Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Phosphorus -total	0.14	0.24	0.43	0.09	38
Banks	Phosphorus -total	0.07	0.13	0.34	0.05	39
McCabe	Phosphorus -total	0.17	0.25	0.32	0.11	2
CK41	Phosphorus -total	0.05	0.15	0.33	0.06	38
DC Afterbay	Phosphorus -total	0.02	0.10	0.27	0.04	39

Location	Avg
NBA	0.24
Banks	0.13
McCabe	0.25
CK41	0.15
DC Afterbay	0.10



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# Summary of State Water Project Mineral Quality Data

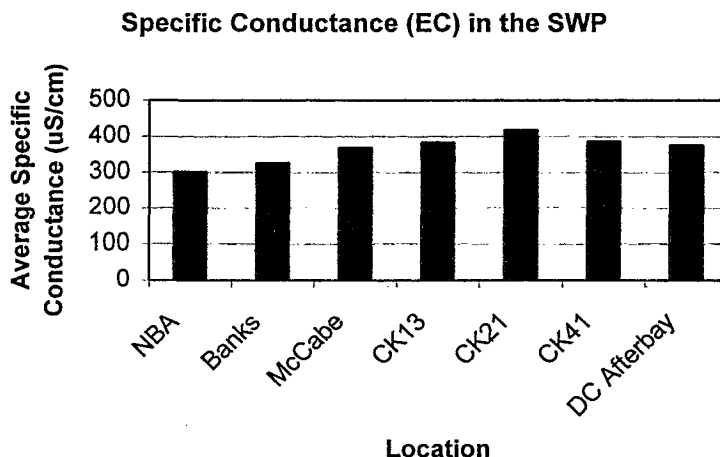
for the period January 1995 through March 1998

Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Specific Conductance	126	302	495	90	38
Banks	Specific Conductance	162	326	643	116	39
McCabe	Specific Conductance	142	368	761	152	39
CK13	Specific Conductance	199	383	682	103	39
CK21	Specific Conductance	237	418	1030	174	39
CK41	Specific Conductance	107	386	684	121	38
DC Afterbay	Specific Conductance	210	376	593	80	37

Unpublished Data  
Subject to Revision

Location	Avg
NBA	302
Banks	326
McCabe	368
CK13	383
CK21	418
CK41	386
DC Afterbay	376

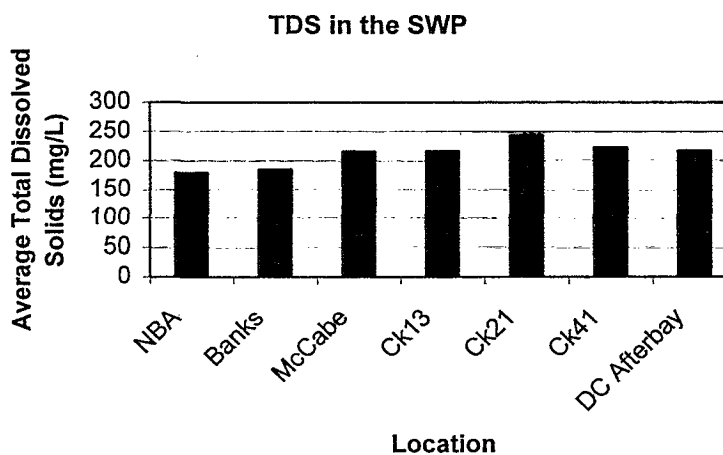
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Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Total Dissolved Solids	88	179	289	49	38
Banks	Total Dissolved Solids	97	185	338	63	39
McCabe	Total Dissolved Solids	86	216	435	84	39
Ck13	Total Dissolved Solids	117	217	324	53	39
Ck21	Total Dissolved Solids	139	244	722	118	39
Ck41	Total Dissolved Solids	80	223	404	69	38
DC Afterbay	Total Dissolved Solids	127	217	345	46	38

Location	Avg
NBA	179
Banks	185
McCabe	216
Ck13	217
Ck21	244
Ck41	223
DC Afterbay	217

Unpublished Data  
Subject to Revision



File: SWPDataSummary.XLS

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# Summary of State Water Project Water Quality Monitoring Data

for the period January 1995 through March 1998

Location	Parameter	Min	Avg	Max	StDev	#Samples
NBA	Bromide	0.01	0.05	0.20	0.03	37
NBA	Carbon-Total Organic	4.0	8.9	21.0	4.8	38
NBA	Nitrate + nitrite	0.02	0.40	3.50	0.56	38
NBA	Phosphorus -total	0.14	0.24	0.43	0.09	38
NBA	Specific Conductance	126	302	495	90	38
NBA	Total Dissolved Solids	88	179	289	49	38
NBA	Trihalomethane Formation	468	957	2011	474	37
Banks	Bromide	0.040	0.125	0.440	0.094	39
Banks	Carbon-Total Organic	3.0	4.1	10.0	1.7	39
Banks	Nitrate + nitrite	0.09	0.61	1.50	0.35	39
Banks	Phosphorus -total	0.07	0.13	0.34	0.05	39
Banks	Specific Conductance	162	326	643	116	39
Banks	Total Dissolved Solids	97	185	338	63	39
Banks	Trihalomethane Formation	283	498	1062	170	38
McCabe	Bromide	0.040	0.139	0.420	0.088	38
McCabe	Carbon-Total Organic	3.0	4.3	15.0	2.2	38
McCabe	Nitrate + nitrite	1.30	1.35	1.40	0.07	2
McCabe	Phosphorus -total	0.17	0.25	0.32	0.11	2
McCabe	Specific Conductance	142	368	761	152	39
McCabe	Total Dissolved Solids	86	216	435	84	39
McCabe	Trihalomethane Formation	304	532	1752	256	38
CK13	Bromide	0.050	0.147	0.430	0.074	38
CK13	Carbon-Total Organic	3.0	4.0	8.0	1.3	38
CK13	Specific Conductance	199	383	682	103	39
CK13	Total Dissolved Solids	117	217	324	53	39
CK13	Trihalomethane Formation	150	492	979	149	37
CK21	Bromide	0.060	0.161	0.390	0.082	14
CK21	Carbon-Total Organic	3.0	4.1	9.0	1.7	14
CK21	Specific Conductance	237	418	1030	174	39
CK21	Total Dissolved Solids	139	244	722	118	39
CK21	Trihalomethane Formation	280	506	949	174	12
CK41	Bromide	0.040	0.170	0.380	0.085	32
CK41	Carbon-Total Organic	3.0	3.9	8.0	1.3	33
CK41	Nitrate + nitrite	0.14	0.70	1.70	0.42	38
CK41	Phosphorus -total	0.05	0.15	0.33	0.06	38
CK41	Specific Conductance	107	386	684	121	38
CK41	Total Dissolved Solids	80	223	404	69	38
CK41	Trihalomethane Formation	267	466	761	132	37
DC Afterbay	Bromide	0.080	0.150	0.280	0.044	34
DC Afterbay	Carbon-Total Organic	2.0	3.5	6.0	1.0	34
DC Afterbay	Nitrate + nitrite	0.14	0.52	1.90	0.27	39
DC Afterbay	Phosphorus -total	0.02	0.10	0.27	0.04	39
DC Afterbay	Specific Conductance	210	376	593	80	37
DC Afterbay	Total Dissolved Solids	127	217	345	46	38
DC Afterbay	Trihalomethane Formation	220	430	949	126	38

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D-035885



**CONTRA COSTA  
WATER DISTRICT**

1331 Concord Avenue  
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September 4, 1998

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*Vice President*

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Bette Boatman

Nobie O. Elcenko, D.C.

Walter J. Bishop  
*General Manager*

Mr. Rick Woodard  
CALFED Bay-Delta Program  
Water Quality Program  
1416 Ninth Street, Suite 1155  
Sacramento, CA 95814

**Subject: Source Water Quality Degradation in Transit**

Dear Mr. Woodard,

In response to your August 26, 1998 memorandum regarding "*Source Water Quality Degradation in Transit*," Contra Costa Water District (CCWD or District) is aware of the potential for degradation of its raw water in transit from the point of diversion to our treatment plants and is continuing its efforts to identify and eliminate any possible sources of contamination. The primary source of contamination is most likely storm drainage into the District's open canals. A description of the District's operations and facilities is attached (Attachment A). A map of CCWD's source water intakes, Los Vaqueros Reservoir and the delivery systems is also attached (Attachment B) along with a more detailed map showing the locations of the water treatment plants (Attachment C).

CCWD operates 4 miles of unlined canal from the trash rack at Rock Slough to Pumping Plant No.1 and approximately 22 miles of concrete lined canal from Pumping Plant No.1 to the turnout for the District's Bollman Treatment Plant.

The unlined portion of the canal is subject to some contamination from drainage inflow and groundwater seepage. The contamination does not cause any noticeable effect on concentrations at times when water is being delivered through the canal because of the substantial dilution. However, at times of low diversions or when the canal is shut down, however, the deterioration is cumulative and noticeable. CCWD is actively pursuing the diversion of drainage away from the canal and the elimination of the only two remaining drain inlets to the canal. The District also has an intensive and on-going monitoring program and has recently applied to the State Water Resources Control Board for a Proposition 204 grant to manage the watershed draining towards Rock Slough and the unlined section of the Contra Costa Canal.

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Source Water Quality Degradation in Transit  
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Page 2

Salinity data collected at Pumping Plant #1 and at Clyde near the District's Bollman Treatment Plant during February 1998 are presented in Attachment D. There does not appear to be any significant increases in salinity as a result of transit in the lined portion of the Contra Costa Canal. There is also no apparent correlations with local precipitation during February 1998.

The lined portion of the canal can potentially be contaminated from drainage inflow or vandalism. The District has an active public education program and a fence maintenance program to reduce vandalism. The District is also close to completing a multi-year drainage study and a spill prevention and response plan. The study showed that the impact of drainage on water quality is generally negligible when the drainage is from watersheds which have controlled access and limited use. However, where the land use of the watersheds causes contamination (e.g., intensive grazing) or where areas with vehicle access could lead to contaminant spills, there is the potential for significant contamination of the Contra Costa Canal.

In response to this, CCWD is continuing its policy of requiring new developments to divert surface drainage away from the canal. Substantial tributary watersheds have been eliminated in recent years. The District is also planning to complete two large drainage control projects during FY99/00. A spill prevention and response plan will be completed by November, 1998.

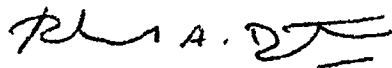
In addition, the District has recently completed the \$450 million Los Vaqueros project which includes a new pipeline between the new 250 cfs intake at Old River near the Highway 4 crossing and the Contra Costa Canal at Pumping Plant #4. CCWD will generally use the Old River intake as its main source of drinking water from the Delta because the salinities are typically lower and to benefit fish (only the Old River intake is currently screened). As a result, a large portion of the District's raw water supply from the Delta will be conveyed through a closed conduit, protecting its quality. In fact, water conveyed to the District's other water treatment plant, the Randall-Bold Plant near Pumping Plant #4, will be conveyed almost completely by pipe.

In summary, the contamination "*in transit*" at the District between the points of diversion and the water treatment plants is negligible unless accidental spills occur. Surface drainage between the trash rack at Rock Slough (the start of the Contra Costa Canal) and the turnout to the Bollman Treatment Plant does not cause a significant change in the concentrations of contaminants present in the source water from the Delta. The District has ongoing efforts to monitor, evaluate, eliminate and control sources of degradation to its canal.

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Please call me at (925) 688-8187 if you have any questions or require additional information.

Sincerely,



Richard A. Denton  
Water Resources Manager

RAD/REO

Attachment A: CCWD Operations and Facilities

Attachment B: Map of CCWD Service Area and Storage and Conveyance Facilities

Attachment C: Map showing location of CCWD's water treatment plants

Attachment D: Discussion of Canal Chlorides variations in February 1998

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### **Attachment A: CCWD OPERATIONS AND FACILITIES**

The Contra Costa Water District ("CCWD") operates raw water distribution facilities, water treatment plants, and treated water distribution facilities. CCWD supplies raw and treated water to Antioch, Concord, Diablo Water District (serving Oakley), Pittsburg, Southern California Water Company (serving Bay Point), Martinez, and parts of Pleasant Hill and Walnut Creek. CCWD serves approximately 400,000 people throughout north-central and east Contra Costa County. Its clients also include 10 major industries, 36 smaller industries and businesses, and 50 agricultural users.

The treated water service area for CCWD encompasses all or part of the cities of Concord, Clayton, Clyde, Pleasant Hill, Walnut Creek, Martinez, and Port Costa. Treated water for this service area is provided from CCWD's Bollman Water Treatment Plant in Concord. The Bollman facility is a 75 MGD conventional plant which is currently being upgraded to include intermediate ozonation. CCWD also supplies treated water to the Diablo Water District ("DWD"), which serves customers in Oakley from a plant jointly owned by CCWD and DWD. The Randall-Bold Water Treatment Plant is a 40 MGD direct/deep-bed filtration plant which utilizes both pre- and post-ozonation to provide a high quality drinking water to the customers in its service area.

Contra Costa Water District is almost entirely dependent on the Delta for its water supply. The Contra Costa Canal and the recently completed Los Vaqueros Project make up CCWD's principal water supply and delivery system. CCWD diverts unregulated flows and regulated flows from storage releases from Shasta, Folsom, and Clair Engle reservoirs into the Sacramento River as a contractor of the Bureau of Reclamation's ("Reclamation") Central Valley Project. Under Water Service Contract I75r-3401 (amended) with Reclamation, CCWD can divert and redivert up to 195,000 acre-feet annually of water from Rock Slough and the new Old River intake. Currently, CCWD uses between about 140,000 af/yr. CCWD can also divert up to 26,780 af/yr of water from Mallard Slough under its own water rights (Water Rights License No.3167 and Permit No.19856). The City of Antioch and Gaylord Container, both customers of CCWD, also have water rights permits to divert water from the Delta.

The Contra Costa Water District has obtained its water supply from the Delta since 1940. Delta water is subject to large variations in salinity and mineral concentrations and this water supply has made CCWD and its customers vulnerable to any man-made or natural sources that could degrade Delta water quality. Water quality changes in Delta water are noticeable to those who drink the water or use the water for commercial and industrial processes. Degradation in water quality is objectionable to many CCWD customers, costly to all residential and industrial users, and a health risk for some individuals. Degradation of Delta water quality impairs the beneficial uses of water supplied by CCWD to its customers.

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The Contra Costa Water District is committed to supplying its customers with the highest quality water practicable and providing all reasonable protection of the supply from any known or potential source of hazardous contamination. CCWD Resolution No. 88-45 states in part that:

"CCWD is committed to reducing the concentration of sodium and chloride in the District's water, thereby reducing household and landscape irrigation concerns and industrial and manufacturing costs caused by the fluctuating sodium and chloride level of CCWD's Delta source...."

In May 1987, CCWD's Board of Directors adopted water quality objectives for water distributed within its service area. The acceptable concentration levels for sodium and chloride were established at 50 milligrams per liter (mg/L) and 65 mg/L, respectively. In 1988, the voter-constituents of CCWD approved the issuance of bonds to finance a \$450 million water quality and reliability project known as the Los Vaqueros Project. The primary purposes of the Los Vaqueros Project are to improve the quality of water supplied to CCWD customers and minimize seasonal quality changes, and to improve the reliability of the emergency water supply available to CCWD. The Los Vaqueros Project consists of a reservoir with 100,000 acre-feet of storage, a new point of diversion (at Old River south of the Highway 4 crossing) which operates in conjunction with the current Rock Slough diversion point, associated water conveyance and delivery facilities, pumping plants, and other facilities.

On June 2, 1994, the State Water Resources Control Board issued Decision 1629 which gives CCWD additional rights to divert and store water for beneficial uses. The State Board subsequently issued Water Rights Permits No. 20749 and 20750 for filling Los Vaqueros Reservoir from the new intake at Old River and diversion and storage of the water of Kellogg Creek (up to 9,640 af/yr). These rights are in addition to the contractual rights to divert and store water furnished through the CVP. Diversion from the Old River intake for delivery to CCWD's service area began in the summer of 1997 and Los Vaqueros reservoir filling began early in 1998. Up to 95,850 AFA may be diverted for storage between November 1 of each year to June 30 of the succeeding year under Water Rights Permit No. 20749.

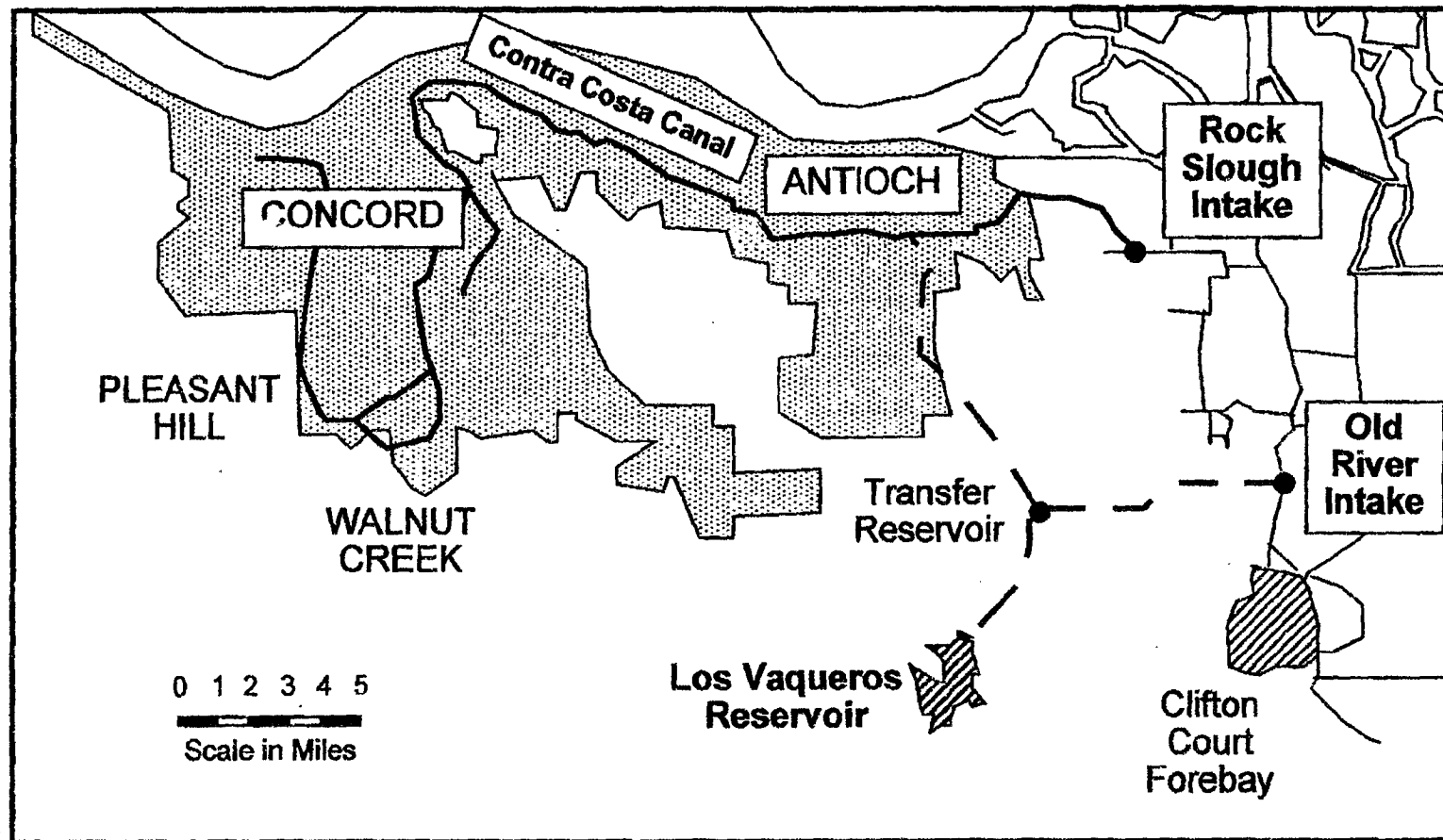
A key to the successful performance of the Los Vaqueros Project is CCWD's ability to fill and continue to refill the reservoir from Old River with high quality water and to use that water for blending when salinities at CCWD's Delta intakes exceed the 65 mg/L chloride goal. Any increases in Delta salinities caused by CVPIA action will increase the demand on blending water from the reservoir while at the same time reducing the availability of high quality water for refilling. CCWD and its 400,000 customers will be impacted through higher pumping costs to replace the extra blending water that is released and through the additional treatment costs, increased corrosion and health effects of delivering higher salinity water.

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## Attachment B

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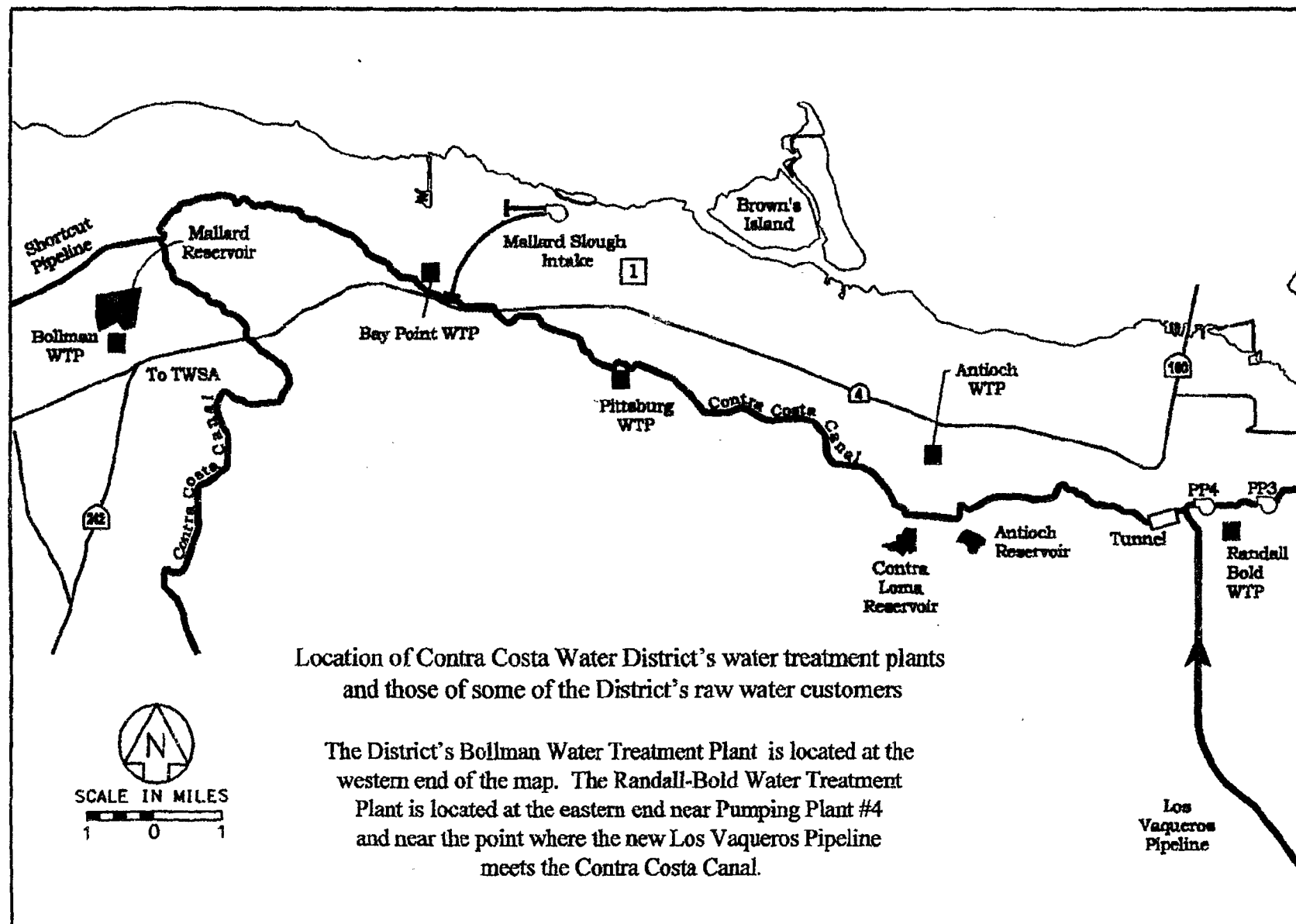
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Map of Contra Costa Water District Service Area  
and Storage and Conveyance Facilities

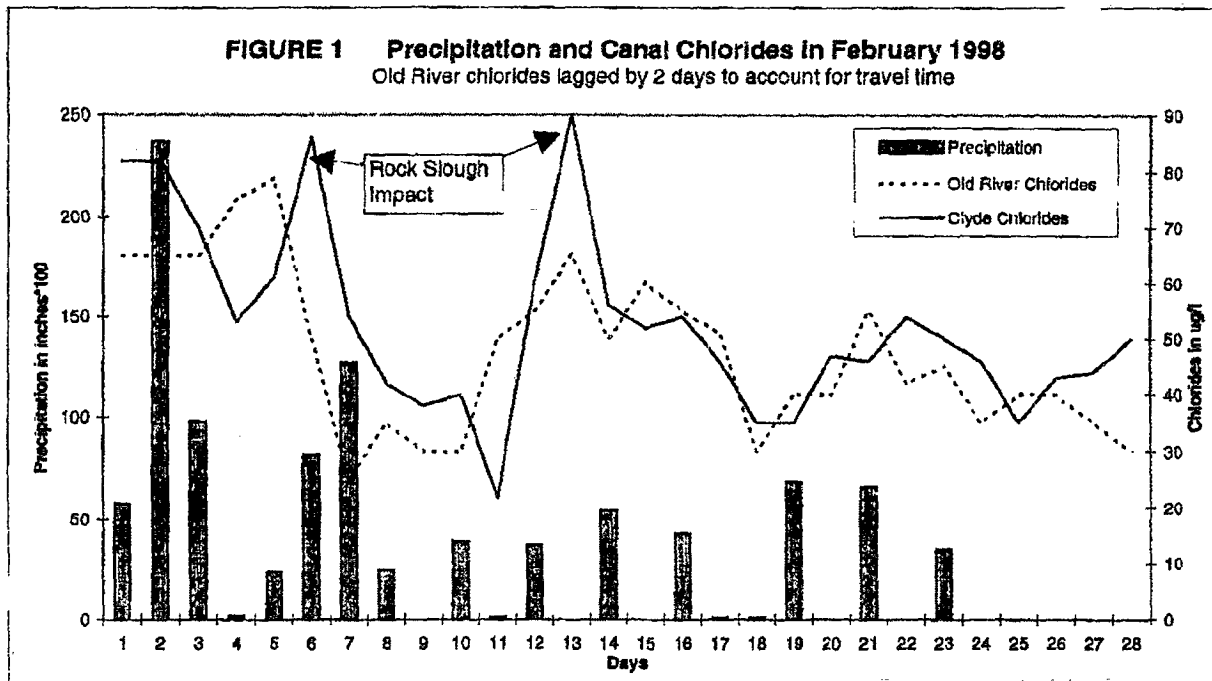
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## Attachment C



NOTE : PIPELINE ALIGNMENTS ARE CONCEPTUAL

## Attachment D



During February of 1998, the Contra Costa Canal was primarily supplied from the Old River Pump Station. During winter conditions (low demand) water travels approximately 2 days from Old River to the Bollman Treatment Plant, i.e. one day through the Los Vaqueros Pipeline and one day through the canal from Oakley to Clyde near the Bollman Treatment Plant. If chloride measurements at Old River are lagged for two days to account for this travel time, the chlorides at Old River and at Clyde correlate well, indicating that there is no increase in chlorides due to drainage.

The precipitation bar graph does not show a strong correlation with the changes in chloride concentrations, which is a further indication that drainage does not increase chlorides.

The two chloride peaks are caused by water from Rock Slough, which was only diverted into the canal for brief periods of time. Rock Slough experiences cumulative increases in chlorides when the Pumping Plants are shut down. The cause of this degradation west of the pumping plants in the unlined portion of the canal is currently being investigated. When pumping resumes at Rock Slough, water with high chloride levels is diverted to the canal until the water which has been trapped in the unlined portion of the canal is replaced with lower chloride water from the Delta.



Summary of Data from Santa Clara Valley Water District								
		Unpublished Data						
		Subject to Revision						
Penitencia Water Treatment Plant (at end of South Bay Aqueduct)								
Parameter	Beginning Date	Ending Date	Min	Avg	Max	StDev	#Samples	Units
Specific Conductance (EC)	4/9/94	9/11/96	121	373	4151	184	890	umhos
MPN 15	4/29/94	9/11/96	1	21	900	41	1654	MPN/100ml
NO3	6/22/94	8/21/96	0.16	1.71	4.82	1.40	29	mg/L
PO4	6/22/94	8/21/96	0.05	0.21	0.80	0.18	25	mg/L
TDS	6/22/94	9/4/96	105	220	350	72	31	mg/L
Penitencia Water Treatment Plant Influent Total Organic Carbon								
Source Water	Beginning Date	Ending Date	Min	Avg	Max	StDev	#Samples	Units
Del Valle Reservoir	2/1/82	11/1/96	2.90	4.15	5.80	1.14	13	mg/L
South Bay Aqueduct	2/1/81	8/1/97	1.80	3.74	6.30	1.07	62	mg/L
San Luis Reservoir	2/1/92	2/1/96	2.37	4.35	7.10	1.53	8	mg/L
Penitencia Water Treatment Plant Influent Bromide								
Source Water	Beginning Date	Ending Date	Min	Avg	Max	StDev	#Samples	Units
Del Valle Reservoir	5/1/82	11/1/96	0.060	0.193	0.400	0.123	7	mg/L
South Bay Aqueduct	1/1/82	8/1/97	0.025	0.321	0.800	0.222	45	mg/L
San Luis Reservoir	2/1/92	2/1/96	0.100	0.219	0.310	0.073	8	mg/L
San Luis Reservoir Monitoring Data								
Parameter	Beginning Date	Ending Date	Min	Avg	Max	StDev	#Samples	Units
TOC	1/1/91	12/1/94	3.1	4.5	6.9	1.2	27	mg/L
TOC	10/11/94	3/9/98	2.0	2.9	4.1	0.6	87	mg/L
Bromide	1/1/91	12/1/94	0.160	0.257	0.480	0.071	30	mg/L
Bromide	10/11/94	4/13/98	0.025	0.218	0.530	0.096	173	mg/L
Nitrate-N	1/1/91	12/1/94	ND	1.06	4.50	0.90	33	mg/L
Nitrate-N	12/6/94	4/13/98	0.42	2.69	4.20	1.02	165	mg/L
Nitrate + Nitrite	1/1/91	12/1/94	1.0	3.3	5.0	1.5	9	mg/L
Ammonia-N	1/1/91	12/1/94	ND	0.04	0.14	0.05	29	mg/L
Phosphate-P	1/1/91	12/1/94	ND	0.15	0.70	0.14	42	mg/L
Phosphate-P	10/11/94	4/13/98	0.03	0.23	1.05	0.13	173	mg/L
		Unpublished Data						
		Subject to Revision						
File: SCVWDSummary.XLS								

**Summary of  
Santa Clara Valley Water District Giardia and Cryptosporidium Data**

**Unpublished Data  
Subject to Revision**

Summary of Cryptosporidium and Giardia data for the period 10/11/94 through 3/9/98:

Of 123 Cryptosporidium samples taken over the period, 44 were collected from Penitencia Water Treatment Plant (at end of South Bay Aqueduct); 82 were collected from Rinconada Water Treatment Plant (on opposite side of Santa Clara Valley from Penitencia in Los Gatos; 87 were collected from Santa Teresa Water Treatment Plant (using San Luis Reservoir water); and 32 were collected in satisfaction of the Information Collection Rule. Most of the samples were collected from plant influents or finished water. 121 of the samples had undetectable concentrations. One sample of Penitencia Water Treatment Plant influent contained 0.4 Cryptosporidium oocysts per 100 liters. One sample from Santa Teresa Water Treatment Plant contained 2 oocysts per 181 liters.

Of 122 Giardia samples collected, one sample from Rinconada Water Treatment Plant influent contained detectable Giardia, at a concentration of 4 per liter.

**Unpublished Data  
Subject to Revision**

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**D - 0 3 5 8 9 5**

D-035895

To: Rick Woodard  
CALFED

From: Roy Wolfe  
Metropolitan Water District of Southern California

Date: September 4, 1998

Subject: Source Water Quality Degradation and Treatment Information

Attached, per your request, is information concerning water quality degradation of supplies in the SWP system, and treatment information for MWD's Mills and Jensen filtration plants that treat SWP water. I am looking forward to the CALFED Bromide Panel deliberations next week and appreciate all your efforts to organize the Bromide Panel. If you require additional information for the Bromide Panel or to assist in developing your response to comments on the Draft PEIS/EIR concerning source water quality degradation in transit, please call me at (213) 217-6241, or Lynda Smith at (916) 650-2632.

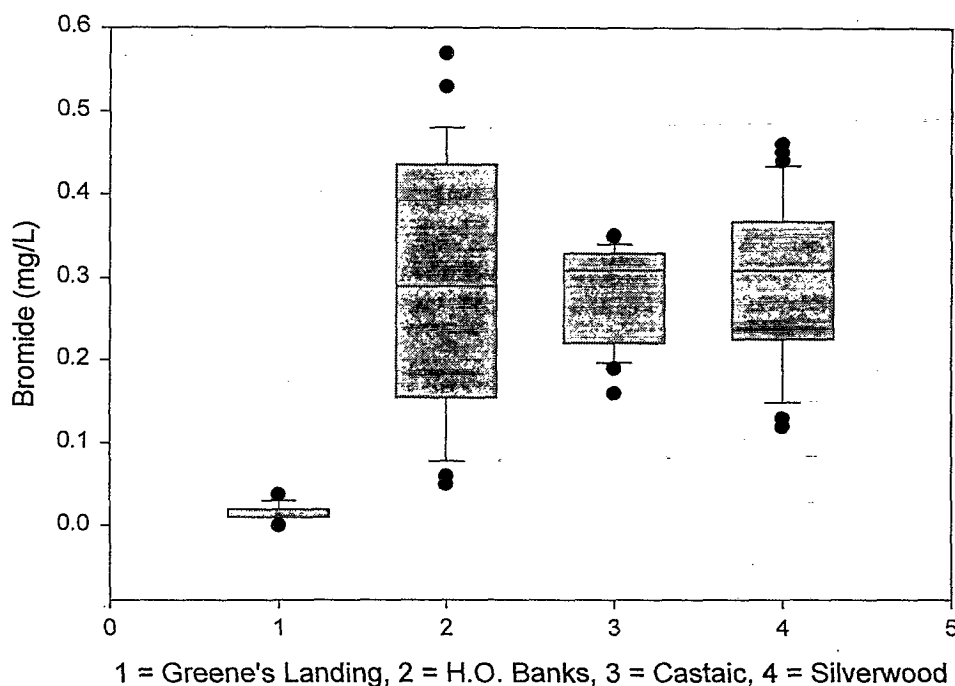
## Source Water Quality Degradation in Transit

Metropolitan Water District of Southern California  
September 4, 1998

Although State Project Water (SPW) can undergo water quality degradation after export from the Delta, the presence of certain contaminants (e.g., bromide) is only due to Delta sources. Figure 1 shows the impact of transit on bromide in SPW. Metropolitan Water District of Southern California (MWD) has been measuring bromide in the Sacramento River at Greene's Landing (above the Delta), water exported from the Delta at H.O. Banks Pumping Plant, and at the effluents of two Southern California reservoirs that store SPW (i.e., Castaic and Silverwood Lakes). These data are part of MWD's monthly or quarterly program to measure simulated distribution system (SDS) disinfection by-product (DBP) formation in SPW.

FIGURE 1

Impact of Transit on Bromide in State Project Water:  
MWD SDS Database (November 1990-August 1995)



The data in Figure 1 were examined using box-and-whisker plots. The bottom and top of the box correspond to the 25th and 75th percentiles, respectively, which is referred to as the interquartile range. The whiskers range from the 10th to the 90th percentiles, with outliers

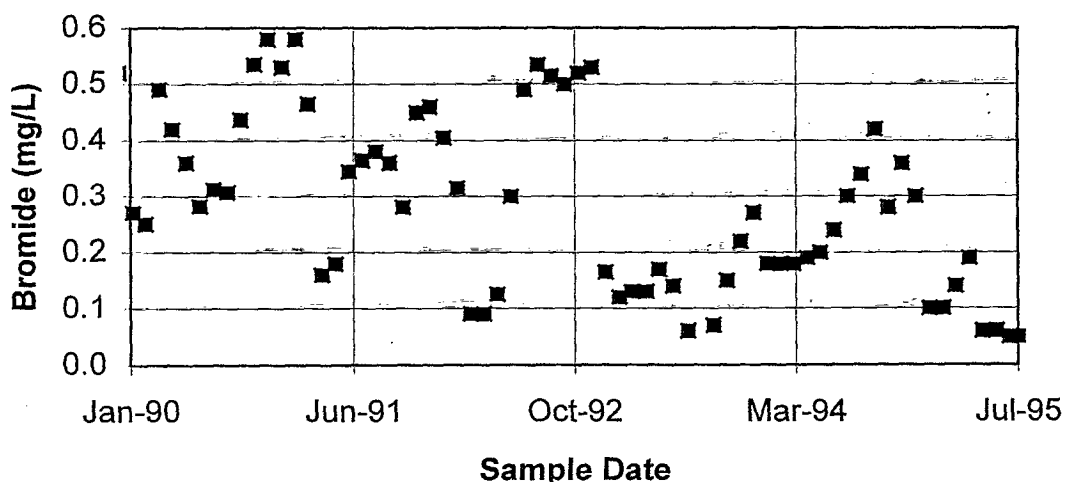
shown as individual data points above or below the whiskers. A solid line that passes horizontally through the box corresponds to the median (50th percentile) value.

The median and 90<sup>th</sup> percentile bromide concentrations for Greene's Landing were 0.02 and 0.03 mg/L, respectively, whereas the median and 90<sup>th</sup> percentile values for H.O. Banks were 0.29 and 0.50 mg/L, respectively. Krasner and colleagues ("Quality Degradation: Implications for DBP Formation," *Journal American Water Works Association*, Vol. 86, No. 6, June 1994, pp. 34-47) have previously demonstrated that saltwater intrusion is the principal source of bromide in water exported from the Delta. Although there is a narrower range of bromide concentrations in the Southern California SPW reservoir effluents, the median value (0.31 mg/L) is the same as measured at H.O. Banks.

The reason for the apparent narrowing of the range of bromide concentrations in the SPW reservoirs is primarily due to "blending" over time. The West Branch of SPW is stored in Pyramid and Castaic Lakes. That system has a detention time of approximately two years. In addition, the Pyramid -- Elderberry Forebay to the Castaic Lake system is used as a pump-back power generation facility by the Los Angeles Department of Water and Power (LADWP). Up to 8,000 acre-feet of water is pumped up to the deepest layer of Pyramid Lake each night. LADWP has the potential to move 18,000 acre-feet from Pyramid to Elderberry during on-peak demand power generation. This process thoroughly mixes the deep volume of Pyramid Lake. The East Branch of SPW is stored in Silverwood Lake, which has a detention time of approximately three months. Figure 2 shows the variability in bromide concentrations at H.O. Banks (a Department of Water Resources [DWR] database was used so as to have monthly data).

FIGURE 2

**Variability in Bromide (Monthly Averages) at H.O. Banks:  
DWR Database (January 1990-August 1995)**



Assuming that H.O. Banks was the only source of water entering the SPW reservoirs, a 2-year and 3-month running average set of bromide values were calculated to estimate what level of bromide would be in the effluents of the two reservoirs based on continuous blending over the detention times in each reservoir system. Figure 3 shows the impact of a 2-year detention time in the Pyramid/Castaic Lake system on the bromide concentration in the West Branch. The estimated values differ from the actual lake effluent values by -1 to 38 percent, with an average value (based on the absolute values) of 18 percent. Although the assumptions in this model effort are simplistic, they do indicate that the narrowing of the range of bromide concentrations simply represents a blending of high and moderate levels of bromide to yield a median value that matches that of the median value in the input water.

**FIGURE 3**

**Impact of Detention Time in Castaic Lake on  
Bromide Concentration in SPW: January 1992-August 1995**

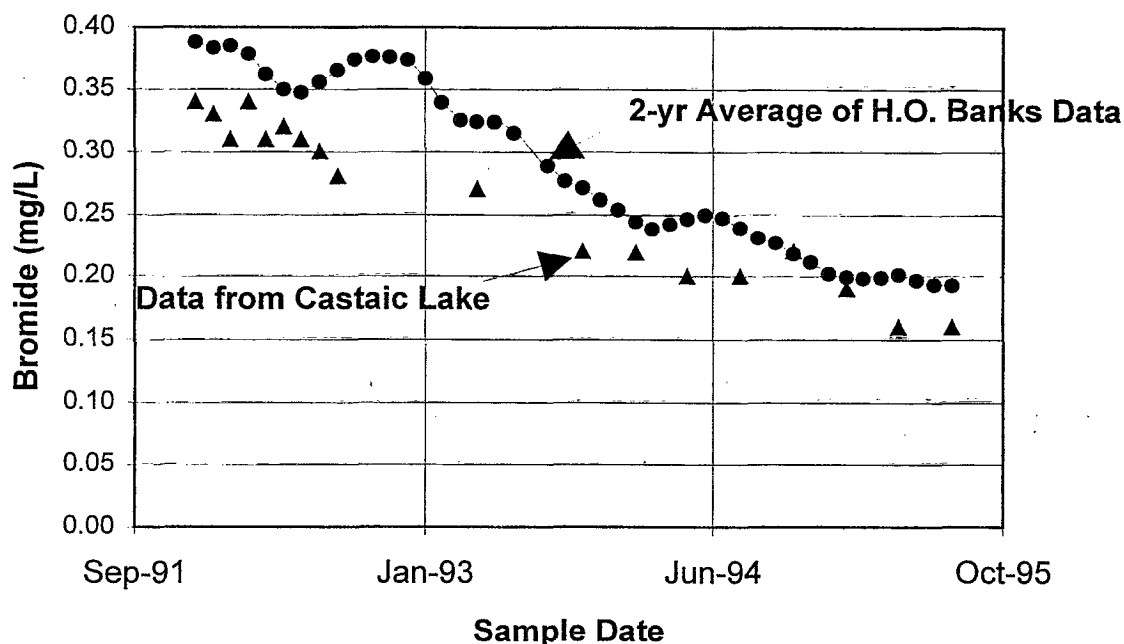


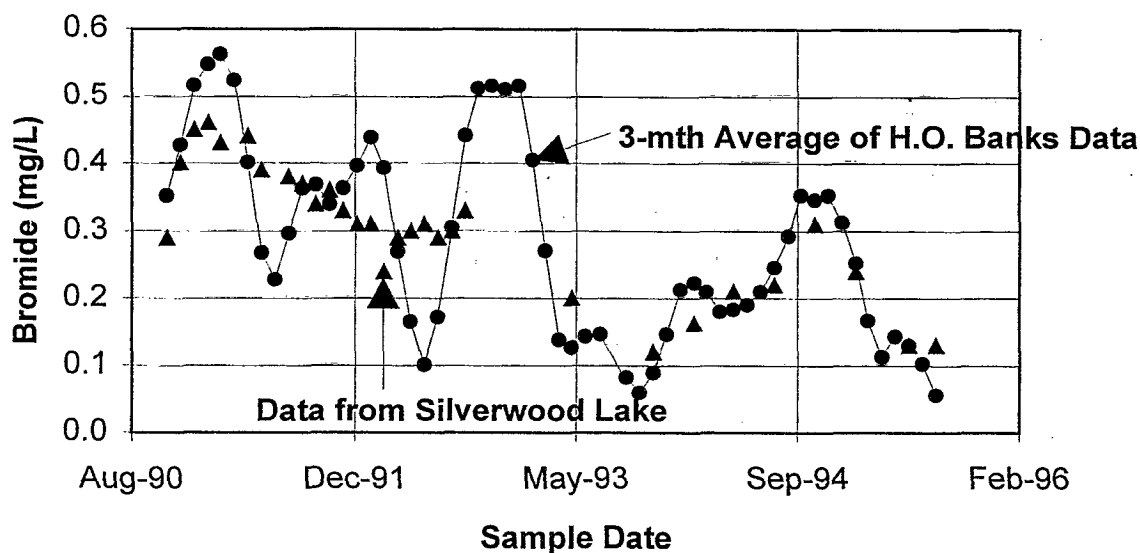
Figure 4 shows the impact of a 3-month detention time in Silverwood Lake on the bromide concentration in the East Branch. The average difference (based on absolute values) is 24 percent. Although the actual values in 1991-92 tend to not have as much variability as the model predicted, the central tendency matches the observed trend. Moreover, actual data collected in 1993-95 match the variability in the predicted values quite well.

Although this modeling effort has focused on water exported from H.O. Banks, SPW traveling south in the California Aqueduct often mixes with federal Central Valley Project (CVP) supplies in jointly operated facilities in the San Luis Field Division. The CVP supplies, which are exported from the Delta through Tracy Pumping Plant and are generally of higher salinity

content than SPW, can be pumped from the CVP's Delta Mendota Canal (DMC) into the California Aqueduct's O'Neill Forebay where the blended water can continue to travel south in the Aqueduct or be pumped into San Luis Reservoir. Because both the state and federal projects are impacted by saltwater intrusion, bromide in SPW in Southern California (below the O'Neill Forebay) is due to Delta sources and not due to sources along the aqueduct or local runoff in Southern California.

**FIGURE 4**

**Impact of Detention Time in Silverwood Lake on  
Bromide Conc. in SPW: Nov. 1990-Aug. 1995**



Bromide levels in SPW are a concern to MWD and other urban water suppliers utilizing Delta water supplies. During chlorination of bromide-containing waters, bromine-containing DBPs of health and regulatory concern (e.g., bromodichloromethane—which has been demonstrated to be a carcinogen and a teratogen) are formed. During ozonation of bromide-containing waters, bromate is formed. Bromate is the most carcinogenic of the DBPs measured to date. Because bromide cannot cost-effectively be removed in a treatment plant prior to disinfection, the best means of controlling bromide is in source water control programs or facilities improvements.

The CALFED process is evaluating storage and conveyance alternatives, including improved Delta transfer facilities. Table 1 shows bromide predictions at H.O. Banks (HOB) and at O'Neill Forebay (ONF) from a modeling effort by MWD's Planning and Resources Division. Baseline represents existing water quality and is the "no action" alternative. Alternative 1 is the existing system with storage. Alternative 2 involves improvements to the through-Delta transfer facility. Alternative 3 is a dual system (through Delta and an isolated facility), with the isolated facility capacity of 7,500 cfs.

In Alternative 3, it is predicted that the bromide concentration would be significantly improved at H.O. Banks, as a high percentage of Sacramento River water from above the Delta would be delivered via an isolated facility. Although CVP water would still be impacted by saltwater intrusion, it is predicted that Alternative 3 would still significantly improve the bromide levels in SPW (a median and 90<sup>th</sup> percentile of 0.09 and 0.15 mg/L, respectively, at O'Neill Forebay). Moreover, improvements in the Delta that minimize saltwater intrusion would also improve the salinity of CVP water exported at Tracy Pumping Plant. Furthermore, as part of the CALFED process, operational changes in how state and federal project waters are delivered are being investigated, such that even more of the benefits of a Delta fix at H.O. Banks can be realized for those systems that take SPW below O'Neill Forebay.

**TABLE 1**  
MWD Model Predictions of Impact of CALFED Alternatives on Bromide (mg/L) in SPW

Percentile	Baseline		Alternative 1		Alternative 2		Alternative 3	
	HOB	ONF	HOB	ONF	HOB	ONF	HOB	ONF
100 <sup>th</sup>	0.72	0.69	0.78	0.75	0.61	0.61	0.34	0.38
90 <sup>th</sup>	0.49	0.48	0.54	0.52	0.29	0.28	0.09	0.15
75 <sup>th</sup>	0.29	0.35	0.36	0.39	0.16	0.18	0.05	0.12
50 <sup>th</sup>	0.13	0.20	0.16	0.25	0.12	0.14	0.02	0.09
25 <sup>th</sup>	0.11	0.14	0.11	0.15	0.08	0.11	0.02	0.06
10 <sup>th</sup>	0.08	0.12	0.09	0.12	0.07	0.09	0.02	0.04
0 <sup>th</sup>	0.04	0.07	0.04	0.06	0.05	0.07	0.02	0.02

Another Delta water quality concern is salinity or total dissolved solids (TDS). Saltwater intrusion into the Delta is the major source of TDS and contributor to the variability of TDS levels in SPW. Other sources of TDS include agricultural drainage, municipal and industrial wastewater discharges, and urban runoff. Once diverted from the Delta, the mixing of SWP and CVP water supplies at O'Neill Forebay can contribute TDS to SPW, particularly during drier periods. In addition, in the past TDS was introduced into the California Aqueduct during groundwater pump-in programs. Moreover, the TDS of treated waters can be significantly increased—by the addition of large amounts of acid and base—when ozonating high-bromide waters at a reduced pH level to minimize bromate formation or during enhanced coagulation at an acidic pH in order to remove total organic carbon (TOC). TDS has a significant impact on the ability to implement groundwater recharge and water recycling programs, and causes economic impacts on residential and industrial water users.

In a DWR database for 1986-1995, the median and 90th percentile values of TDS at Greene's Landing were 104 and 130 mg/L, respectively, whereas the median and 90th percentile concentrations at H.O. Banks were 276 and 395 mg/L, respectively. In an MWD database for 1987-1998, the median and 90th percentile values of TDS in West Branch SPW were 349 and 407 mg/L, respectively, whereas the median and 90th percentile concentrations in East Branch SPW were 298 and 391 mg/L, respectively.



A Delta fix that lowered the salinity in SPW exported at H.O. Banks would (1) significantly lower the TDS in the Southern California SPW reservoirs, even if mixing of SWP and CVP water supplies at O'Neill Forebay and San Luis Reservoir continued, and (2) would lower the bromide in SPW such that plants using ozone would be able to discontinue or minimize acid addition, which would result in lower TDS levels in the finished water.

Another water quality constituent of concern in Delta water supplies is TOC. The sources of TOC include agricultural drains in the Delta, and urban and agricultural discharges in the Sacramento and San Joaquin River Basins. Delta Island agricultural drainage contributes about 50% of the in-Delta load of TOC. TOC is a surrogate parameter for organic DBP precursors. The proposed DBP Rule includes removal requirements for TOC in addition to the maximum contaminant levels (MCLs) for the DBPs. The TOC in agricultural drains has a higher proportion of humic substances than the channel waters, and humic substances are higher in DBP formation potential than nonhumic substances. Thus, agricultural drains in the Delta not only increase the amount of TOC in Delta waters, but increase their reactivity to form DBPs. Furthermore, TOC increases the disinfectant demand of the water, requiring higher chlorine or ozone doses in order to meet disinfection requirements. High amounts of disinfectants translate to increased formation of DBPs, thus compounding the problem. Bromate formation is also increased in the presence of higher amounts of TOC. Finally, when ozonation is used, a certain percentage of the TOC is converted to assimilable organic carbon (AOC). Thus, increases in TOC can result in an increase in the microbial regrowth potential in the finished-water distribution system.

In a DWR database for 1989-1995, the median and 90th percentile values of TOC at Greene's Landing were 2.2 and 4.1 mg/L, respectively, whereas the median and 90th percentile concentrations at H.O. Banks were 3.3 and 5.5 mg/L, respectively. In the MWD database, the median and 90th percentile values of TOC in West Branch SPW were 2.7 and 3.1 mg/L, respectively, whereas the median and 90th percentile concentrations in East Branch SPW were 2.9 and 3.8 mg/L, respectively.

Although there are other sources of TDS that can enter the California Aqueduct, there are no significant local sources of TOC in the SWP system below O'Neill Forebay. The TOC data do not indicate any TOC degradation in transit, rather a blending out of the TOC in the Southern California reservoirs. The source of TOC south of O'Neill Forebay is mostly algae growing in the aqueduct or the storage reservoirs along the SWP system. The aqueduct is a flow-through system with sufficient depth to limit production due to shading. Additionally, the reservoirs are relatively deep providing a small photosynthetic zone to decomposition zone. As a result, south of O'Neill Forebay the photosynthetic inputs of organic carbon are balanced by heterotrophic decomposition of organic carbon. A Delta fix that lowers the TOC in SPW exported from the Delta would lower the concentration of TOC in the Southern California SPW reservoirs.

In summary, the above analysis shows that the SWP supplies exported from the Delta at H.O. Banks Pumping Plant are of poor quality with respect to levels of bromide, TDS and TOC, due to sources within the Delta and the watersheds tributary to the Delta. The above analysis also shows that significant water quality degradation is not occurring in the SWP system between

the point of diversion in the Delta and the drinking water treatment plants in Southern California. A Delta solution that significantly improves the bromide, TDS and TOC in water supplies exported from the Delta would result in significant improvements in water quality in SPW delivered to Southern California.

SWK

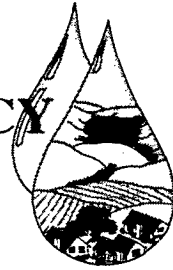
	Temp.	Coagulant Dose (mg/L)		Cl <sub>2</sub> Dose	Floc.	Inact. Ratio (actual/ 0.5-log Giardia)	Bromide	Inf. TOC	Eff. TOC	TOC Rem.	Trihalomethanes (µg/L)				
Date	(°C)	Alum/FecCl <sub>3</sub>	Polymer	(mg/L)	pH		(mg/L)	(mg/L)	(mg/L)	(%)	CHCl <sub>3</sub>	CHCl <sub>2</sub> Br	CHClBr <sub>2</sub>	CHBr <sub>3</sub>	TTHM
Jan-90				0.75											
Feb-90							0.3	2.52	2.26	10.3					
Mar-90		6.2		2.00											
Apr-90		5.0		2.23											
May-90		4.7		3.40			0.4	2.79	2.59	7.2					
Jun-90		3.8		3.07			0.38				1	2	2	0	6
Jul-90											1	3	3	1	8
Aug-90		5.5		2.16											
Sep-90		5.8		2.32			0.34	2.66	2.49	6.4	2	4	5	2	13
Oct-90		5.7		2.47			0.32				2	5	7	3	17
Nov-90		3.1		2.27			0.26				3	4	3	1	10
Dec-90		3.4		2.13			0.3	2.64	2.38	9.8	2	3	3	1	8
Jan-91		3.4		2.07			0.41				1	2	2	1	6
Feb-91		3.9		1.99			0.46				1	3	3	1	8
Mar-91		4.6		5.30			0.46	2.84	2.52	11.3	2	4	4	2	11
Apr-91				2.70			0.42				3	6	6	2	16
May-91				3.54			0.09				9	11	12	3	34
Jun-91		6.5		3.83			0.12	3.17	2.75	13.2	11	15	16	5	47
Jul-91		7.4		4.30			0.4				9	23	41	18	91
Aug-91		6.9		3.73			0.38				2	3	2	0	7
Sep-91		4.8		3.69			0.38	3.62	3.36	7.2	4	5	4	1	14
Oct-91		3.7		3.50			0.37				7	22	46	20	95
Nov-91		4.0		2.22			0.36				2	3	3	1	8
Dec-91		4.1		2.10			0.36	2.36	2.30	2.5	2	2	2	1	7
Jan-92		3.1		2.53			0.35				1	2	2	1	6
Feb-92		3.9		2.09			0.32				2	3	2	1	7
Mar-92		5.0		2.62			0.33	2.56	2.40	6.3	2	2	2	1	7
Apr-92		5.7		2.93			0.3				2	3	2	1	8
May-92		5.5		2.11			0.26				3	4	2	0	10
Jun-92		5.6		3.98			0.26	3.47	3.39	2.3	21	31	35	8	95
Jul-92		6.0		4.45			0.29				19	34	40	10	103
Aug-92		6.1		4.73			0.28				30	47	60	14	151
Sep-92		6.6		4.39			0.31	3.67	3.52	4.1	15	29	43	12	99
Oct-92		5.9		4.23			0.32				13	28	45	13	99
Nov-92		6.0		4.10			0.35				9	25	50	20	104
Dec-92		4.9		3.50			0.39	3.03	3.19	-5.3	4	16	42	27	89
Jan-93		5.9		3.59			0.4				2	12	35	29	78
Feb-93		8.3		3.72			0.36				5	18	34	17	74
Mar-93		11.2		3.81			0.31	3.14	2.93	6.7	13	25	28	6	72
Mar-93		12.2		3.81			0.22				21	26	18	2	67

## Mills plant

Date	Temp.	Coagulant Dose (mg/L)		Cl <sub>2</sub> Dose	Floc.	Inact. Ratio (actual/ 0.5-log Giardia)	Bromide	Inf. TOC	Eff. TOC	TOC Rem.	Trihalomethanes (µg/L)				
	(°C)	Alum/FeCl <sub>3</sub>	Polymer	(mg/L)	pH		(mg/L)	(mg/L)	(mg/L)	(%)	CHCl <sub>3</sub>	CHCl <sub>2</sub> Br	CHClBr <sub>2</sub>	CHBr <sub>3</sub>	TTHM
Apr-93		8.1		3.76			0.22				16	21	17	2	56
May-93		6.9		4.06			0.31	3.10	3.10	0.0	19	25	21	2	67
Jun-93		7.0		5.00			0.23				33	39	30	3	105
Jul-93		5.9		4.95			0.21				57	53	34	4	148
Aug-93		6.0		4.47			0.18	3.75	3.62	3.5	28	31	25	3	87
Sep-93		5.8		4.31			0.15				29	30	21	2	82
Oct-93		3.0		3.74			0.13				23	23	17	2	65
Nov-93		2.9		3.65			0.12	2.25	2.25	0.0	20	20	14	2	56
Dec-93		2.7		3.07			0.1				15	19	16	2	52
Jan-94		4.8		2.61			0.14				13	17	16	2	48
Feb-94		3.7		2.77			0.16	3.12	2.83	9.3	14	20	17	3	54
Mar-94		4.1		2.87			0.41				2	8	23	23	55
Apr-94		6.3		3.92			0.18		3.48		19	24	18	2	63
May-94		5.0		4.15			0.22	3.57	3.49	2.2	27	33	27	2	89
Jun-94		4.4		3.92			0.23	3.06	3.00	2.0	20	29	28	6	83
Jul-94		3.7		3.86			0.21	3.21	3.16	1.6	27	37	37	7	108
Aug-94		3.0		3.81			0.22	3.05	2.90	4.9	15	23	27	6	71
Sep-94		2.8		3.74			0.21	3.19	3.08	3.4	16	28	40	9	93
Oct-94		2.6		3.58			0.27	2.69	2.84	-5.6	10	22	34	9	75
Nov-94		2.4		3.33			0.29	2.40	2.26	5.8	10	20	36	14	80
Dec-94		1.5		3.05			0.35	3.27	2.40	26.6	3	11	26	14	54
Jan-95		2.2		3.82			0.32	2.27	2.20	3.1	8	19	33	14	74
Feb-95		1.8		4.11			0.29	2.67	2.64	1.1	11	23	33	9	76
Mar-95		1.9		4.35			0.24	2.77	2.71	2.2	17	28	28	5	78
Apr-95		3.0		4.22			0.2	3.21	2.97	7.5	26	30	22	2	80
May-95		3.6		4.99			0.19	3.32	3.16	4.8	34	31	17	2	83
Jun-95		4.2		5.28			0.14	3.55	3.00	15.5	60	38	16	1	115
Jul-95		5.3		4.67			0.1	2.95	2.60	11.9	53	37	14	1	105
Aug-95		4.9		4.19			0.11	2.77	2.60	6.1					
Sep-95		3.6		4.08			0.14	2.90	2.77	4.5	25	24	16	1	66
Oct-95		3.2		4.22			0.12	2.69	2.44	9.3	24	24	16	2	66
Nov-95		2.3		4.07			0.38	3.27	2.48	24.2	3	15	37	24	79
Dec-95		2.0		4.01			0.15	3.27	2.98	8.9	3	8	27	22	60
Jan-96		3.1		4.31				3.25	3.19	1.8					
Feb-96		8.4		5.05			0.18	2.67	2.46	7.9	18	18	13	2	51
Mar-96		9.0		5.13				3.17	2.32	26.8	27	19	8	1	55
Apr-96		6.0		5.11			0.12	3.42	3.01	12.0	36	20	9	1	65
May-96		3.6		5.20			0.15	2.86	2.56	10.5	37	26	14	1	78
Jun-96		4.0		5.03			0.17	2.99	2.78	7.0	21	22	18	3	64

02

# SOLANO COUNTY WATER AGENCY



August 31, 1998

Rick Woodard, Manager, Water Quality Program  
CALFED Bay Delta Program  
1416 9<sup>th</sup> Street, Suite 1155  
Sacramento, CA 95814

Dear Rick:

I have received your memorandum dated August 26, 1998 regarding source water quality degradation in transit. You requested technical information regarding the hypothesis that degradation source water quality between points of diversion in the Delta and drinking water treatment plant intakes is significant.

The North Bay Aqueduct is an underground pipeline so we do not have water quality degradation from the pumping plant to the treatment plants. We have submitted extensive comments to the CALFED Bay Delta Program on water quality problems at the North Bay Aqueduct however these are at the point of diversion, not between the point of diversion and the water treatment plants. We do not have any of the information you are requesting.

I appreciate you keeping me informed of water quality activities of the CALFED Bay Delta Program. If you have any questions or need any additional information please contact me at (707) 451-2904.

Sincerely,

David B. Okita  
General Manager

Cc: Elaine Archibald

N82.8-27-98.let

508 Elmira Road, Vacaville, California 95687  
(707) 451-2852, FAX (707) 448-7347



D - 0 3 5 9 0 7

D-035907

# Pesticides

61

D - 0 3 5 9 0 8

## Chapter 9. New Parameter Study

The purpose of the New Parameter Study was to determine the concentrations of newly or soon to be regulated constituents in Delta water, and to determine if it is necessary to add more parameters to the routine MWQI monitoring schedule. The Study was planned to be conducted from June 1995 through June 1997. The results of this Study were designed to provide information which could be used to: (1) obtain monitoring waivers for constituents, (2) provide data that can be used to satisfy a system's initial sampling requirements, (3) provide data that may be used to evaluate future best available technology (BAT) requirements.

The Phase II and Phase V rules under the USEPA's drinking water regulations establishes limits for several organic and inorganic chemicals. In addition, California has established new MCLs for a number of constituents. The New Parameter Study was designed to gather information for the newly regulated constituents, for which little historical data was available.

The California DHS has the authority to grant waivers to compliance monitoring requirements. Waivers are based on a vulnerability assessment, or prior analysis, or both. Waiver determinations are based on a contaminant-by-contaminant basis. At this time DHS, has not developed standard guidelines for obtaining a waiver. Therefore, it was not possible to model this Study on known waiver requirements. Consequently, the Study was designed based on the current standard compliance monitoring requirements.

### Study Parameters

The analytical parameters included in the Study are listed in Table 9-1, New Parameter Study List of Parameters. With a few exceptions, this list includes most of the newly or soon to be regulated parameters. The list of Study parameters includes some parameters that are monitored under the MWQI Program.

The pathogens, including *Giardia* and *Cryptosporidium*, were not proposed for monitoring under this Study. The MWQI program has developed a Study to address these constituents. The D/DBPs are not included on the list of parameters. D/DBPs are formed during the water treatment process and are not likely to be found in the source water. A MWQI Study is underway to simulate the formation of D/DBPs in a distribution system using Delta waters as source water.

Although waivers may be granted on a vulnerability assessment alone, DWR conducted analyses for all parameters listed in Table 9-1 for the following reasons: (1) DHS has not developed standard waiver guidelines and may require monitoring results in the future; and (2) analytical laboratories charge based on the method, not the number of parameters analyzed for in each method.



**Table 9-1. Municipal Water Quality Investigations  
New Parameter Study  
List of Parameters**

1,1,1,2-Tetrachloroethane	Dinoseb
1,1,2,2-Tetrachloroethane	Diquat
1,1,2-Trichloroethane	Di-2(ethylhexyl)adipate
1,1-Dichloropropane	Di-2(ethylhexyl)phthalate
1,2,4-Trichlorobenzene	Endothall
1,2-Dibromoethane (EDB)	Endrin
1,2-Dichloropropane	Ethylbenzene
1,3-Dichloropropane	Ethylene thiourea
2,2-Dichloropropane	Fluorotrichloromethane
2,3,7,8-TCDD	Glyphosate
2,4,5-T	Heptachlor
2,4,5-TP	Heptachlor epoxide
2,4-D	Hexachlorobenzene
3-Hydroxycarbofuran	Hexachlorobutadiene
Acifluorfen	Hexachlorocyclopentadiene
Acrylonitrile	Hexachloroethane
Alachlor	Lindane
Aldicarb	Manganese
Aldicarb sulfone	Mercury
Aldicarb sulfoxide	Methomyl
Aldrin	Methoxychlor
Antimony	Methyl tertiary butyl ether
Asbestos	Methylene chloride
Atrazine	Metolachlor
Barium	Metribuzin
Benzo(a)pyrene	Molybdenum
Beryllium	Nickel
Boron	Nitrate
Bromacil	Nitrate-Nitrite (Total)
Bromobenzene	Nitrite
Bromochloroacetonitrile	Oxamyl
Bromomethane	o-Chlorotoluene
Butachlor	o-Dichlorobenzene
Cadmium	PCBs
Carbaryl	Pentachlorophenol
Carbofuran	Picloram
Chlordane	Prometon
Chlorobenzene	Propachlor
Chloroethane	p-Chlorotoluene
Chloromethane	Selenium
Chromium	Simazine
cis-1,2-Dichloroethylene	Styrene
Cyanazine	Sulfate
Cyanide	Tetrachloroethylene
Dalapon	Thallium
Dibromoacetonitrile	Toluene
Dibromochloropropane	Toxaphene
Dicamba	trans-1,2-Dichloroethylene
Dichloroacetonitrile	Trichloroacetonitrile
Dichlorodifluoromethane	Trichloropropane
Dichloroethane	Trifluralin
Dichloropropene	Xylenes (Total)
Dieldrin	Zinc

## **Sampling Sites**

The sample sites consist of the major sites of diversion from the Delta: Barker Slough Pumping Plant, Contra Costa Pumping Plant, Delta-Mendota Canal, and Banks Pumping Plant. Old River near Byron was added as a sampling site in June 1996.

## **Timing of Sampling**

Sample collection began in June 1995 and continued quarterly during September, December, and March. This report includes results for October 1, 1995 through December 31, 1996 (see Table 9-2, New Parameter Study 1995/96 Sample Results). Summary results for the parameters were detected during the Study and are discussed in this report and included in Table 9-3, Summary of New Parameter Study Detections, June 1995 through December 1996.

## **Continued Monitoring**

Study results were used to determine whether certain parameters should be added to routine MWQI monitoring, based on their frequency and level of detection.

## **Regulatory Update**

The following is an update of the regulations that apply to this Study. A list of applicable parameters, analytical methods, and corresponding federal regulations are shown in Table 9-2.

## **Phase II Rule**

The Phase II Rule for synthetic organic compounds and inorganic compounds was finalized in two notices published on January 30, 1991 and July 1, 1991. The rule regulates 38 organic and inorganic chemicals. As part of the Phase II requirements, systems must monitor for contaminants based on a 9-year compliance cycle. The 9-year compliance cycle contains three 3-year compliance periods.

In addition to the 38 regulated compounds, Phase II requires monitoring for 30 unregulated contaminants. All systems monitor at a minimum or base requirement concentration for the contaminant or contaminant group unless a waiver has been granted by the State. Waivers to sampling requirements are available to all systems at

**Table 9-2. Study Parameters, Analytical Methods, and Regulations**

Method	Constituents	Regulation	MCL mg/L
<b>Inorganics</b>			
204.2	Antimony	Phase II, V	0.006
	Asbestos	Phase II	7 mil fibers/L
208.1	Barium	Phase II	2
210.2	Beryllium	Phase II, V	0.004
212.3	Boron	Phase VIB	0.6
213.2	Cadmium	Phase VIB	0.005
218.2	Chromium	Phase II	0.1
335.2	Cyanide	Phase II, V	0.2
243.2	Manganese	Phase VIB	0.2
245.2	Mercury	Phase II	0.002
246.2	Molybdenum	Phase VIB	0.04
249.2	Nickel	Phase II, V	0.1
352.1	Nitrate	Phase II	10 (as N)
354.1	Nitrite	Phase II	10 (as N)
270.3	Selenium	Phase II	0.05
375.2	Sulfate	Phase II, V, Sulfate Rule	
279.2	Thallium	Phase II, V	0.002
353.2	Total nitrate-nitrite	Phase II	10 (as N)
289.2	Zinc	Phase VIB	2
<b>Organics</b>			
<b>507</b>	<b>Nitrogen and Phosphorus Pesticides</b>		
	Bromacil	Phase VI B	
	Butachlor	Phase II	
	Metolachlor	Phase II, VIB	0.1
	Metribuzin	Phase II, VIB	0.2
	Prometon	Phase VIB	
<b>508</b>	<b>Chlorinated Pesticides</b>		
	Aldrin	Phase II	
	Cyanazine	Phase VIB	0.001
	Dieldrin	Phase II	
	Endrin	Phase V	0.002
	Heptachlor	Phase II	0.0004
	Heptachlor epoxide	Phase II	0.0002
	Lindane	Phase II	0.0002
	Methoxychlor	Phase II	0.04
	PCBs	Phase II	0.0005
	Propachlor	Phase II	
	Toxaphene	Phase II	0.003
	Trifluralin	Phase VIB	0.005
<b>513</b>	2,3,7,8 -TCDD	Phase II,V	3 X 10 exp(-8)

**Table 9-2. Study Parameters, Analytical Methods, and Regulations (cont.)**

<b>Method</b>	<b>Constituents</b>	<b>Regulation</b>	<b>MCL mg/L</b>
<b>515.2</b>	<b>Chlorinated Herbicides</b>		
	Dalapon	Phase II, V	0.2
	2,4,5-T	Priority List	
	2,4,5-TP	Phase II	0.05
	2,4-D	Phase II	0.07
	Acifluorfen	Phase VIB	0.002
	Dicamba	Phase II, VIB	0.2
	Dinoseb	Phase II, V	0.007
	Pentachlorophenol	Phase II	0.001
	Picloram	Phase II, V	0.5
<b>524.2</b>	<b>Volatile Organics</b>		
	Hexachlorobutadiene	Phase VIB	0.001
	1,2-Dibromoethane (EDB)	Phase II	0.00005
	o-Dichlorobenzene	Phase II	0.6
	1,2,4-Trichlorobenzene	Phase V	0.07
	Chlorobenzene	Phase II	0.1
	Ethylbenzene	Phase II	0.7
	Fluorotrichloromethane	Priority List	
	trans-1,2-Dichloroethylene	Phase II	0.1
	1,1,1, 2-Tetrachloroethane	Phase VIB	0.07
	1,1,2,2-Tetrachloroethane	Phase VIB	
	1,1-Dichloropropene	Priority List	
	1,2-Dichloropropane	Phase II	0.005
	1,3-Dichloropropane	Priority List	
	2,2-Dichloropropane	Priority List	
	Bromobenzene	Priority List	
	Bromomethane	Phase VIB	0.01
	Chloroethane	Priority List	
	Chloromethane	Priority List	
	cis-1,2-Dichloroethylene	Phase II	0.07
	Dichlorodifluoromethane	Priority List	
	Dichloroethane	Phase VIB	
	Methylene Chloride	Phase V	0.005
	o-Chlorotoluene	Priority List	
	p-Chlorotoluene	Priority List	
	Styrene	Phase II	0.1
	Toluene	Phase II	<sup>1</sup>
	Trichloropropane	Phase VI B	0.0008
	Xylenes (total)	Phase II	10
	1, 1,2-Trichloroethane	Phase V	0.005
	Hexachloroethane	Priority List	
	Methyl tertiary butyl ether	Phase VI B	
	Dichloropropene	Phase VI B	0.0006
	Acrylonitrile	Phase VIB	0.003

**Table 9-2. Study Parameters, Analytical Methods, and Regulations (cont.)**

<b>Method</b>	<b>Constituents</b>	<b>Regulation</b>	<b>MCL mg/L</b>
<b>521.1</b>	<b>Base, Neutrals, Acids, &amp; Pesticides</b>		
	Di-2(ethyhexyl)adipate	Phase II, V	0.4
	Di-2(ethyhexyl)phthalate	Phase II, V	0.006
	Simazine	Phase II, V	0.004
	Chlordane	Phase II	0.002
	Alachlor	Phase II	0.002
	Atrazine	Phase II	0.003
	Benzo(a)-pyrene	Phase II, V	0.0002
	Hexachlorobenzene	Phase II, V	0.001
	Hexachlorocyclopentadiene	Phase II, V	0.05
<b>531.1</b>	<b>Carbamates</b>		
	3-Hydroxycarbazure	Phase II	
	Aldicarb	Phase II	0.003
	Aldicarb sulfone	Phase II	0.002
	Aldicarb sulfoxide	Phase II	0.004
	Carbaryl	Phase II	
	Carbofuran	Phase II	0.04
	Oxamyl	Phase II, V	0.2
	Methomyl	Phase II, VIB	0.2
<b>547</b>	<b>Glyphosate</b>	<b>Phase II, V</b>	<b>0.7</b>
<b>548</b>	<b>Endothall</b>	<b>Phase II, V</b>	<b>0.1</b>
<b>549</b>	<b>Diquat</b>	<b>Phase II, V</b>	<b>0.02</b>
<b>551</b>	<b>Chlorinated Byproducts &amp; Solvents</b>		
	Dibromochloropropane	Phase II	0.0002
	Bromochloroacetonitrile	Priority List	
	Dibromoacetonitrile	Priority List	
	Dichloroacetonitrile	Priority List	
	Tetrachloroethylene	Phase II	0.005
	Trichloroacetonitrile	Priority List	
<b>553</b>	<b>Ethylene Thiourea</b>	<b>Phase VIB</b>	<b>0.025</b>

**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
Barker Slough Pumping Plant         Equal to MCL	Arsenic	June 95 September 95 December 95 March 96 June 96 September 96 December 96	0.002 0.003 0.002 0.002 0.003 0.003 0.002	**Arsenic Rule	0.05	0.05
	Barium	June 95 March 96	.13 0.062	Phase II	2	1
	2,4,-D	June 95 September 95	0.001 0.002	Phase II	0.07	1
	Bis(2-ethyl-hexyl)phthalate	September 96	0.004	Phase II, V	0.006	0.004
	Formetenate Hydrochloride	June 96	0.001			
	Manganese	September 95 December 95 March 96 June 96 September 96	0.014 0.043 0.016 0.015 0.025	**Phase VIB	0.05 (SMCL)	0.05 (SMCL)
	Nickel	December 95	0.005	Phase II, V	.1	.1
	Simazine	March 96	0.001	Phase II, V	0.004	0.004
	Zinc	June 95 September 95 December 95 March 96 September 96	0.021 0.011 0.008 0.028 0.015	**Phase VIB	5 (2 proposed)	5

**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996 (cont.)**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
Contra Costa Pumping Plant	Arsenic	June 95	0.002	**Arsenic Rule	0.05	0.05
		September 95	0.002			
		December 95	0.002			
		March 96	0.002			
		June 96	0.003			
		September 96	0.002			
		December 96	0.002			
	Bis(2-ethylhexyl) phthalate	September 96	0.007	Phase II,V	0.006	0.004
Exceeded MCL	2,4-D	June 95 September 95	0.001 0.002	Phase II	0.07	1
	2,4,5-T	June 95	0.001	Priority List		
	Copper	June 96	0.007		TT(1.3) <sup>c</sup>	1 (SMCL)
	Manganese	June 95	0.018	**Phase VIB	0.05 (SMCL)	0.05 (SMCL)
		September 95	0.011			
		December 95	0.015			
		June 96	0.021			
	Simazine	March 96	0.001	Phase II, V	0.004	0.004
	Zinc	June 95 December 95 March 96 September 96	0.011 0.008 0.005 0.006	**Phase VIB	5 (2 proposed)	5
Delta-Mendota Canal	Arsenic	June 95	0.002			
		September 95	0.002			
		December 95	0.002			
		March 96	0.001			
		June 96	0.001			
	Barium	September 96	0.002	Phase II	2	1
		December 96	0.001			
	Manganese	September 95	0.023	** Phase VIB	0.05 (SMCL)	0.05 (SMCL)
		December 95	0.018			
		March 96	0.032			
		September 96	0.026			
		December 96	0.022			

**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996 (cont.)**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
	Selenium	September 95 September 96	0.001 0.002	Phase II	0.05	0.05
	Zinc	June 95 September 95 December 95 March 96 June 96 September 96 December 96	0.002 00.026 0.014 0.012 0.014 0.018 0.013	**Phase VIB	5 (2 proposed)	5



**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996 (cont.)**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
Old River near Byron  (not added until June 1996)	Aminomethylphosphoric Acid	September 96	0.1	Phase II	2	1
	Arsenic	June 96 September 96	0.002 0.002	**Arsenic Rule	0.05	0.05
	Barium	December 96	0.074			
	2,4-D	June 96	0.003	Phase II	0.07	1
	Glyphosate	September 96	0.1	Phase II, V	.7	.7
	Maganese	June 96 September 96 December 96	0.026 0.026 0.017	**Phase VIB	0.05 (SMCL)	0.05 (SMCL)
	Zinc	June 96 September 96 December 96	0.008 0.008 0.007	**Phase VIB	5 (2 proposed)	5

**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996 (cont.)**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
Banks Pumping Plant	Arsenic	September 95 December 95 March 96 September 96 December 96	0.002 0.002 0.001 0.002 0.001	**Arsenic Rule	0.05	0.05
	Barium	June 95	0.13	Phase II	2	1
	Copper	December 95	0.008		TT(1.3) <sup>TT</sup>	1 (SMCL)
	2,4-D	June 95	0.001	Phase II	0.07	1
	Dalapon	December 96	0.002	Phase II, V	0.2	0.2
	Manganese	September 95 December 95 March 96 June 96 September 96 December 96	0.009 0.008 0.033 0.026 0.012 0.014	**Phase VIB	0.05 (SMCL)	0.05 (SMCL)
	Zinc	September 95 December 95 March 96 June 96 September 96	0.008 0.010 0.012 4.33 0.007	**Phase VIB	5 (2 proposed)	5
Old River @ Bacon Island	Arsenic	June 95 September 95 December 95 March 96 June 96	0.001 0.002 0.002 0.001 0.002	**Arsenic Rule	0.05	0.05
	Barium	June 95 March 96	0.052 0.056	Phase II	2	1
	2,4-D	June 95 June 96	0.001 0.001	Phase II	0.07	1

**Table 9-3. Summary of New Parameter Study Detections  
June 1995 through December 1996 (cont.)**

Sample Site	Constituent Detected	Date Detected	Result (mg/L)	Regulation	Federal MCL (mg/L)	State MCL (mg/L)
	Diquat	September 95	0.01	Phase II, V	0.02	0.02
	Manganese	June 95	0.022	**Phase VIB	0.05 (SMCL)	0.05 (SMCL)
		September 95	0.007			
		December 95	0.007			
		June 96	0.010			
		September 96	0.010			
		December 96	0.008			
	Zinc	June 95	0.005	**Phase VIB	5 (2 proposed)	5
		September 95	0.013			
		December 95	0.014			
		March 96	0.022			
		June 96	0.008			
		September 96	0.016			

\* Exceeds primary or secondary MCL.

\*\* Not proposed.

TT = Treatment technique (TT) triggered at Action Level of 1300 ppb.

SMCL = Secondary Maximum Contaminant Level.

the State's discretion, based on a vulnerability assessment or prior analytical results, or both. Waiver determinations are made by the State on a contaminant-by-contaminant basis.

Five of the original 38 chemicals proposed in Phase II were repropoed in a separate rule known as Phase IIB. These chemicals are aldicarb, aldicarb sulfoxide, aldicarb sulfone, pentachlorophenol, and barium. The final Phase II was published in the Federal Register on July 1, 1991 and became effective in January 1, 1993. The State has adopted Phase II and IIB Rules. In some cases, like toluene and monochlorobenzene, the State's MCLs are more stringent than federal MCLs.

#### Phase V Rule

The final Phase V Rule was promulgated on July 17, 1992. The rule regulates 13 Synthetic Organic Chemicals, 5 Inorganic Chemicals, and 3 Volatile Organic Chemicals. Although sulfate was included in the proposed regulation, because of its potentially high treatment cost and mild health risk, it was deleted from the final rule. A proposed Sulfate Rule is expected by May 31, 1998.

Phase V established Maximum Contaminant Level Goals, MCLs, laboratory criteria, and BAT for these 23 contaminants. These regulations apply to all community and nontransient noncommunity systems. Public water systems with 150 or more connections were to begin monitoring in the first compliance from January 1, 1993 to December 31, 1995. Smaller systems are to begin monitoring from January 1, 1996 to December 31, 1999.

Initial monitoring waivers are based on vulnerability assessments. Although initial monitoring waivers are only allowable for the SOCs and cyanide, reduced monitoring may be possible for many contaminants if sampling results show no detections or concentrations "consistently" below the MCLs. However, monitoring may have to be increased if sampling results are higher than "trigger" levels set for contaminants. The State has adopted the Phase V Rule.

#### Phase VIB

When Congress amended the Safe Drinking Water Act in 1986, it required the USEPA to regulate 25 new contaminants every three years. Phase VIB was the last set of contaminants proposed to be regulated. Many of the contaminants in Phase VIB had little health-based data, and could be costly to control in water treatment systems.

The proposed rule was supposed to be published by February 28, 1995; however, the USEPA requested an extension to October 21, 1996. The August 1996 SDWA Amendments suspended developmental work on Phase VIB. The previous law's demand for USEPA to develop 25 new standards every three years was replaced with a new process based on occurrence, relative risk and cost benefit analyses.

USEPA will select at least five new candidate contaminants to consider for regulation every five years. Regulation must be geared toward contaminants posing the greatest health risks. Because lab costs are based on the analytical method used, as opposed to the constituent, there would be no cost savings for eliminating Phase VIB parameters from this Study. Therefore, Phase VIB parameters continue to be included in the Study.

#### Proposed Federal Sulfate Rule

A federal rule for sulfate was proposed by USEPA in the December 20, 1994 Federal Register. This rule sets both the MCLG and MCL for sulfate at 500 mg/L. The rule was originally proposed in 1990 with a larger group of contaminants, but was deferred because of the significant economic effects on a number of water systems.

The proposed rule would affect all community water systems and noncommunity water systems, including transient water systems. In addition to compliance with the sulfate MCL, systems operators will be required to provide alternative water and public education/notification to targeted, sensitive populations. Alternative water is defined as either bottled water that is in compliance with all USEPA MCLs, or water treated by point of use or point of entry devices.

In the August 1996 SDWA Amendments, USEPA and the Center for Disease Control were directed to study the health risk effects of sulfate in drinking water within 30 months. USEPA must include sulfate as one of the five contaminants to be considered for regulation in the first five-year cycle of the regulatory process.

#### Federal Lead and Copper Rule

The final Lead and Copper Rule was promulgated by USEPA on June 7, 1991 (56 FR 26460). Corrections to this rule were published on July 15, 1991 and June 29, 1992. On July 12, 1996, USEPA published notice that it was considering making changes to the national water standard and invited comments to be received by July 11, 1996. These regulations will not affect the rule's basic requirements. Rather, they are intended to reduce the reporting burden of the rule and to respond to a legal challenge by the Natural Resources Defense Council on the exclusion of Transient Noncommunity Water Systems from coverage under the old rule.

The effective date for monitoring was July 7, 1991. The remaining regulations, including action levels and treatment requirements, became effective on December 7, 1992. Final lead and copper regulations call for treatment techniques.

Treatment techniques consist of:

- Optimal corrosion control treatment
- Source water treatment

- Public education
- Lead service line replacement

The August 1996 SDWA Amendments made it unlawful to use lead-containing products in installation or repair of any public water systems or any facility providing water for human consumption. It will be unlawful to manufacture any plumbing fitting or pipe that is not lead-free after August 1998.

The first flush water samples from consumers' taps will be monitored. If more than 10 percent of these samples contain greater than the action level of 0.015 mg/L for lead, or 1.3 mg/L for copper, three required actions must be taken. These requirements are corrosion control treatment, source water treatment, and public education. If a system continues to exceed the lead action level, lead service lines will have to be replaced.

The Lead and Copper Rule also eliminated the lead MCL of 0.05 mg/L and the copper secondary MCL of 1.0 mg/L. The federal MCLGs of 0 and 1.3 mg/L have been set for lead and copper, respectively.

### **Arsenic Rule**

USEPA was under a court-ordered deadline to propose revised regulations for arsenic no later than November 30, 1995. USEPA did not make the deadline and received an extension for this rule through the 1996 SDWA Amendments. USEPA is required to conduct additional research on arsenic, particularly the health effects at low levels of exposure. USEPA must propose a regulation for Arsenic not later than January 1, 2000, and issue a final regulation 12 months later.

### **QA/QC Summary**

#### Holding Times

Holding times for total cyanide, nitrate, nitrate+nitrite, and dissolved nitrite were exceeded in December 1995 by five to six days. Sampling stations where exceedances occurred include Contra Costa Pumping Plant, Old River at Bacon Island, and Delta Pumping Plant Headworks. The holding time for cyanide exceeded at Barker Slough Pumping Plant by six days. No other holding time exceedances were identified.

#### Matrix Spikes

Matrix spikes provide information on the accuracy of the sample results in an environmental sample. The accuracy of sample results is often less in environmental samples due to matrix interferences. The matrix spikes are prepared by adding a known concentration of method analytes to an environmental sample. Similar to

laboratory control samples, one matrix spike are generally prepared for every 10 samples.

The matrix spike recovery for sample number C960406 exceeded the lower control limit by 7 percent. However, since the laboratory control sample for Molybdenum was within control limits for the batch analyzed, there is no QC problem associated with sample number C960406.

The following exceedances were identified for December 1996 samples. The upper control limits on sample number C962329 for 2,4-D and Dalapon were exceeded by 32 and 25 percent, respectively. However, since the LCS recoveries were within control limits for the two analytes, the exceedances are attributed to matrix effects. The lower control limit for Picloram was also exceeded on C962329 by 12 percent which is attributed to the laboratory method used by BSK Laboratories for Picloram recoveries.

#### Laboratory Control Samples

Laboratory control samples provide information on the accuracy of the sample results. Laboratory control samples are prepared by adding a known concentration of method analyte(s) to a clean matrix. Generally, one laboratory control sample is prepared for every 10 samples, otherwise known as a "batch".

The upper control limits were slightly exceeded for Hexachlorocyclopentadiene, Dieldrin, and Heptachlor epoxide for sample numbers X on X. These exceedances are not significant because results for the analytes in question were all below detection limits. The upper control limits were slightly exceeded in December 1996 for Chlorothalonil, Endrin, Methoxychlor, and Hexachlorobenzene for sample number C962330. These extracts have a background level of interference peaks which contribute to these high recoveries according to BSK. The lower control limit for Thiobencarb was also exceeded by 2 percent for sample number C962330.

#### Method Blanks

Method blanks are a blank sample which contain any reagents which may be used in the sample preparation and analysis procedure. The preferred outcome from analysis of method blanks is a less than detectable concentration of the analyte of interest. No method blank exceedances were identified.

#### Field Duplicates

For field duplicates, results are compared using a relative percent difference between the duplicate results. As a general rule for field duplicates, an RPD of up to 15 percent is acceptable for metals, 20 percent for inorganics, and 30 percent for organics. No field duplicate RPD exceedances were identified.

## Summary of Sampling Results for June 1995 through December 1996

Table 9-3, Summary of New Parameter Detections, shows parameters of significance that were detected in at least one of the seven sampling periods. For the purposes of this Study, "significant" parameters include all pesticides and metals that are not part of MWQI routine monitoring.

*Arsenic* is consistently present at all of the sample sites at levels well below the State and federal MCL's. The herbicide *2,4-D* was detected at most of the sampling sites in June 1995 and at Barker Slough and Contra Costa Pumping Plant in September 1995. Levels were in the range of 0.001 to 0.002 mg/L, well below the State and federal MCL's of 1.0 and 0.07 mg/L, respectively. *Bis(2-ethylhexyl) phthalate* (also known as DEHP) is a manufactured chemical found in plastics and sometimes in pesticides. DEHP was detected in September 1996 at Barker Slough at a level of 0.004 mg/L and at Contra Costa Pumping Plant at a level of 0.007 mg/L. Levels of DEHP at Barker Slough are equal to the State MCL of 0.004 mg/L, but less than the federal MCL of 0.006 mg/L. September DEHP levels at Contra Costa Pumping Plant exceeded both the State and federal MCL's. In June 1996, the insecticide *formetenate hydrochloride* (also known as Carzol) was detected at the reporting limit of 0.001 mg/L at Barker Slough. There is no federal or State MCL that regulates it. This constituent is a common lab contaminant and could possibly be a false detect. The herbicide *Simazine* was detected at Barker Slough and Contra Costa Pumping Plant in March 1996 at a level of 0.001 mg/L, below the MCL of 0.004 mg/L. *Zinc* was detected regularly at all of the sampling sites at relatively low levels, with one exception. In June 1996, the Zinc level at Banks Pumping Plant was measured at 4.33 mg/L. The current MCL for Zinc is 5 mg/L.

The pesticide *2,4,5-T* was detected at Contra Costa Pumping Plant at a level of 0.001 mg/L. There are no MCL's set for this constituent, however it is on USEPA's Priority Pollutant List. *Dalapon* was detected at Banks Pumping Plant in December 1996 at a level of 0.002 mg/L, which is below the MCL of 0.2 mg/L. Dalapon is a chlorinated herbicide commonly used in citrus grove ditches and drainage ditches. Sometimes it is used in combination with 2,4-D. *Selenium* was detected at the Delta-Mendota Canal in both September of 1995 and 1996 (at 0.001mg/L and 0.002 mg/L, respectively). The MCL for Selenium is 0.05 mg/L. The insecticide *aminomethyl-phosphoric acid* was detected at Old River near Byron at a level of 0.1 mg/L. The pesticide *Glyphosate* was detected in September 1996 at Old River near Byron at a level of 0.1 mg/L, well below the MCL of 0.07 mg/L. *Diquat* was also detected at Old River at 0.01 mg/L. The MCL for Diquat is 0.02 mg/L.

Overall, the Barker Slough and Contra Costa Pumping Plant Sampling Sites had the greatest occurrence of pesticides. The high amount of agricultural land use in the area may be a large contributor. The pesticide detected most often was 2,4-D. This parameter was consistently detected during June and September. There were several isolated occurrences of different pesticides at all of the sites, with the exception of the



Delta-Mendota Canal, where no pesticides were detected. The only pesticide that exceeded MCLs was DEHP in September 1996 at the Contra Costa Pumping Plant and at Barker Slough.

A complete listing of sample results from October 1995 through December 1996 is in Table 9-4, New Parameter Study 1995/96 Sample Results.

## **The Delta as a Drinking Water Source - Water Quality Issues**

### Issue

The Delta is the major source of drinking water in California. However, contaminants in Delta water have made it very expensive for water purveyors to comply with recent federal regulations and it is not clear how they will be able to comply with potential future drinking water standards.

### The Delta as a Source of Drinking Water

Roughly two thirds of California's population obtains its drinking water from the Sacramento Delta which is formed by the confluence of the Sacramento and San Joaquin Rivers. Two major water projects draw supplies from the Delta: the State Water Project (SWP) and the federally operated Central Valley Project (CVP). A third entity, Contra Costa Water District, (CCWD) also draws its water supply from the Delta.

The SWP and the CVP both divert water in the southern part of the Delta near the City of Tracy. Although both projects divert from locations that are in close physical proximity to one another, the flow paths are such that the SWP diverts more water from the Sacramento River than does the CVP, which draws mostly from the San Joaquin River. Since the San Joaquin River has much poorer quality water, CVP is less suitable for use as a drinking water supply.

The SWP serves 30 public water agencies, which supply drinking water to communities in the North and South Bay Area as well as in Southern California. Roughly 60% of the exported water is used for municipal and industrial purposes, and the rest is used for agriculture. The State has contracts to supply 4.2 million acre-feet (MAF) per year to its member agencies, but can reliably supply only 2.4 MAF per year in its current configuration. This limitation is imposed both by the physical capacity of the system and by water quality considerations in the Delta. The SWP diverts water from two locations in the Delta. A small amount of water is taken from the north Delta, at a point near the City of Fairfield, for use by north Bay Area communities. A much larger amount is diverted from the south Delta for use by communities in Southern California, the central coastal area, the San Joaquin Valley, the south Bay Area, and the Livermore Valley.

The CVP was designed to provide irrigation water to growers in the Sacramento and San Joaquin valleys. The CVP has a south delta pumping capacity of some 2.8 MAF per year, which is used almost entirely to supply farms in the San Joaquin Valley. The CVP has a tremendous impact on the operation of the SWP, however, due to a Coordinated Operating Agreement designed to meet mutual water quality and supply objectives. In addition, the two systems share a common reservoir at a point roughly 50 miles south of the Delta diversions.

The CCWD diverts water from the south Delta for use by communities in Contra Costa County. The points of diversion CCWD uses are in areas that are less influenced by poor water from the San Joaquin River, but are more subject to seawater intrusion than either the SWP or the CVP.

#### Contaminants Affecting Delta Water Quality

Several water quality parameters have been identified as being of particular concern to water systems using the Delta as a source of supply. These include organic carbon, bromide, and disease-causing microorganisms (pathogens).

*Total Organic Carbon (TOC)* is produced by decaying vegetation and other organic detritus. Water flowing through the delta increases in TOC content as the result of the introduction of agricultural drainage, urban runoff, runoff from wetland areas, and treated sewage discharges. TOC reacts with chemicals (principally chlorine) used to disinfect drinking water supplies to form disinfection byproducts with potential health impacts.

*Bromides* are introduced into Delta water supplies primarily by intrusion of seawater (which is high in bromides) into the delta. The degree of this intrusion varies daily, seasonally, and from year to year, depending upon tidal fluctuations and the flow in the Sacramento and San Joaquin Rivers. Bromides can react with chlorine and TOC to form brominated byproducts, but are an even greater concern to water systems using ozone as the primary disinfectant. Ozone reacts with bromide to form bromate, which is considered a potent carcinogen. At this time, there is no economical means of removing either bromide or bromate from water. Bromate formation can be minimized, however, by foregoing the use of ozone as a disinfectant, or by using a water source with a lower concentration of bromide.

*Pathogens* can be introduced into the Delta water by drainage from animal enclosures and cattle grazing areas, urban runoff, and treated sewage discharges. Of principal concern are the protozoa *cryptosporidium* and *giardia*. These organisms, especially *cryptosporidium*, are very difficult to kill using chemical disinfectant. Although testing for them is very problematic due to the insensitivity of currently available analytical techniques, the presence of potential sources of *cryptosporidium* on delta watersheds makes it necessary to assume there is a potential problem with *cryptosporidium* and *giardia*. Water treatment systems deal with them by optimizing their removal by filtration and/or by using ozone, which is a much more powerful disinfectant than chlorine.

#### The Current Problem

The fundamental issue is whether drinking water suppliers using the Delta will be able to meet future drinking water standards, given the water quality problems inherent in the Delta. Unfortunately, current health effects research and treatment technology information do not now provide an adequate scientific basis from which to project what

the drinking water standards, or the treatment options to meet those standards, will be over the next five to ten years. Longer-range projections are even more uncertain.

### Regulatory Situation

In November of 1998, the U.S. Environmental Protection Agency (USEPA) will promulgate new regulations that will make more stringent drinking water standards for disinfection byproducts (known as Stage 1 DBP) while tightening requirements on the treatment of surface water for larger water systems (systems with greater than 10,000 population).

The new standards for disinfection byproducts address three types of byproducts that may be produced when chlorine and/or ozone are used as the primary water disinfecting agent. They are as follows:

Byproduct	New Standard, micrograms per liter (ug/l)	(Old) Standard
Total trihalomethanes (TTHMs)	80	100
Total haloaceticacids (HAAs) (includes five haloaceticacids)	60	N/A
Bromate	10	N/A

The new disinfection byproducts regulation will affect all community water systems. The previous regulation was specific to TTHMs and only affected community water systems serving greater than 10,000 population.

The new surface water treatment requirements (Interim Enhanced Surface Water Treatment Rule) is intended to address the concerns associated with the transmission of *cryptosporidium*. Larger water systems will be required to meet more stringent performance standards and improve on the operation of their treatment facilities.

Currently most water systems using Delta water are able to meet the requirements of these two new regulations. They have accomplished this by: 1) changing from chlorine disinfection to the use of chloramines to reduce disinfection byproducts; and 2) optimizing their treatment operations and using ozone as a primary disinfectant in combination with chloramines.

### Future Regulations

USEPA has established a regulatory schedule that will require two future revisions of both the disinfection byproducts regulation (DBP) and the surface water treatment rule (SWTR). The DBP rule is scheduled to be revised in mid 2002 and then again in 2007. The SWTR is scheduled for revision in late 2000 and again in 2002.

USEPA has indicated that discussions on the first DBP rule revision (known as Stage 2 DBP) will begin in December, 1998. The process will follow the Regulatory Negotiation framework that USEPA has employed in the past.

The outcome of the Stage 2 DBP rule could have a profound effect on water systems using Delta water. Any tightening of the requirements could result in serious compliance problems for water systems. For example, a study commissioned in 1997 by the California Urban Water Association found that if the bromate standard were set at 5 ug/l, water systems using ozone as a primary disinfectant would be unable to comply. In addition, the study found that if the TTHM standard was reduced to 40 ug/l and the THAA standard reduced to 30 ug/l, water systems using chlorine as a primary disinfectant could not comply without extensive capital improvements.

#### Research Affecting Future Regulations

To support the future DBP rules, USEPA is undertaking a significant research effort on the health effects of disinfection byproducts. In February, 1998, a USEPA expert panel was convened to review recent toxicological and epidemiological studies of reproductive and developmental effects associated with DBPs and to consider whether additional epidemiological studies of reproductive and developmental effects would likely yield information to help USEPA develop drinking water standards or strategies for reducing the formation of DBPs of health concern. To date USEPA's focus has been on the cancer causing properties of DBPs. The report contains a number of recommendations for studies that are intended to provide USEPA with information on reproductive and developmental effects for use in establishing the Stage 2 DBP rule.

The panel also reviewed the recent report by the Department of Health Services that found an association between spontaneous abortions and certain levels of trihalomethanes in drinking water. The panel found the study to be well-designed and recommended that: 1) additional work be done to refine the study results; and 2) a similar study be conducted in another location. USEPA agreed with the panel's recommendations and has committed funds to carry them out. A schedule of the DBP Reproductive Epidemiology studies is attached.

USEPA has also committed significant funds to studying the cancer and reproductive toxicology of disinfection byproducts. These studies are scheduled for completion between 1999 and 2004 (schedule of studies attached).

#### Conclusion

Delta water quality will continue to affect the ability of water systems to comply with federal and state drinking water standards. The most significant Delta water quality concern presently is bromide since many larger water systems are converting to ozone as the primary disinfectant to meet the new rule for surface water treatment and still must control bromate production. Any further tightening of federal standards for disinfection

byproducts beyond the Stage 1 DBP rule has the potential for causing serious compliance problems for water systems of all sizes. Therefore, the water systems that use the SWP generally support the construction of a diversion point in the Delta upstream (peripheral canal) of the areas where TOC and bromide cause problems. The diversion point is consistent with the industry principle of providing the highest quality product possible at a reasonable cost and eliminates issues relating to treatment technologies to remove TOC and bromide. Environmental impacts on the Delta and other parts of California would also need to be factored into the public policy decisions.

## Scientists to be Contacted on Health Effects Issues And their Areas of Expertise

### Contact

### Area of Expertise

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USEPA Schedule of Studies  
DBP REPRODUCTIVE EPIDEMIOLOGY

Project	Status	Completion Date
Expert panel report on future DBP repro epi research	Complete	4/98
Improve exposure assessment in California study cohort	1. Low birthweight paper in progress 2. GIS analysis (SAB, LBW) in progress 3. Improve THM, add HA, redo SAB analysis, add male repro and delayed conception	1. 1998 2. 1999 3. 2000 - 2001
Study of DBP exposures and birth weight in Colorado	1. Pilot study on LBW, paper submitted 2. Distribution system model, paper submitted 3. Expanded study on LBW in progress	1. 1998 2. 1999 3. 1999
Collaborative study with CDC on birth defects	Protocol in development	2000
Evaluate methods for conducting male reproductive studies	1. Container development 2. Pilot container	1. 1998 2. 1999
<i>M/DBP Council:</i> Evaluation of geographic areas for future studies	Analysis of available health and exposure information throughout the U.S. is progressing satisfactorily	1998
California-type study in another location	Funds earmarked; Solicitation toward end of year; study begins 1999	2002



## USEPA Schedule of Studies

DBP REPRODUCTIVE TOXICOLOGY

Project	Status	Completion Date
<i>35-day screening studies (NTP)</i>		
Bromodichloromethane	Just completed - negative	Pending
Chlorodibromomethane	Completed - negative	Report available
Bromochloroacetic acid	Just completed - positive	Pending
Chlorodibromoacetic acid	Not yet initiated	1999
Dibromoacetone	Completed - negative	Pending
Bromoacetone	Completed - high dose effect	Pending
Bromate	Completed - high dose effect	Report available
Hexachloropropanone	Completed - high dose effect	Pending
Haloacetic acid mixture	Initiated	1999
<i>Embryotoxicity studies</i>		
Effects of haloacetic acids, bromate, and chlorate in embryo culture	Completed	1999
Haloacetic acid effects on protein kinases	Underway	2000
<i>Developmental toxicity studies</i>		
In vivo screens of DCA, BCA and bromate in pregnant mouse	Underway (oxidative damage, effect on kinase activity)	2000
<i>Reproductive toxicity studies</i>		
Dibromoacetic acid (rabbits)	Award pending (CSU)	2001
Effects of BDCM and BCA on reproduction in female rats	Underway (in-house)	2000
BCA studies in adult male	Underway (in-house)	2000
<i>Long-term DBP study</i> 2-generation study	In planning stages	>2000

## USEPA Schedule of Studies

**DBP CANCER TOXICOLOGY**

Project	Status	Completion Date
<i>2-Year Cancer Bioassays (NTP)</i> Bromodichloromethane Dibromoacetic acid Bromochloroacetic acid Dichloroacetic acid Dibromoacetonitrile Chlorate MX	Most of these are in the initial stages of planning and chemistry analysis.	2002 - 2003 2002 - 2003 2003 - 2004 2003 - 2004 2003 - 2004 2002 - 2003 2003 - 2004
<i>EPA mechanistic research</i>  Dichloroacetic acid  Bromate  Bromodichloromethane    Dibromochloromethane and bromoform  Dibromoacetic acid Bromodichloroacetic acid Bromochloroacetic acid	  Mechanistic studies underway in support of a BBDR <sup>1</sup> model  Mechanistic studies underway  Pharmacokinetic studies underway in support of PBPK <sup>2</sup> models  Mechanistic studies underway in support of a BBDR model  Mechanistic and pharmacokinetic studies underway  Screening/mechanistic studies (Bull) Screening/mechanistic studies (Bull) Screening/mechanistic studies (Bull)	    1998 (rodent model) 2000 (human model)  2000  1999-2000  Early 1999 Early 1999 Early 1999
<i>DBP mixtures studies</i>  Mechanism-based (Wolf et al.)  THM toxicity (Simmons et al.)	  In planning stage  Assessment of additivity assumption; Chlorination/ozonation mixture comparison	  2000 ?  1997-1999 2000

<sup>1</sup> BBDR = biologically based dose-response

<sup>2</sup> PBPK = physiologically based pharmacokinetic

# THE SIGNIFICANCE OF BROMIDE ON THE DRINKING WATER QUALITY OF SACRAMENTO-SAN JOAQUIN DELTA WATERS

## Introduction

Waters of the Sacramento-San Joaquin Delta serve nearly 22 million people living in the Bay-Delta region and southern California. The Delta as a drinking water supply is, therefore, important to the public health and economy of the State.

Municipalities taking water from the Delta are currently faced with an array of challenges. Besides having to compete for increasingly scarce water supplies, new State and federal drinking water regulations are requiring increasing levels of treatment. The cost of treating Delta waters to meet the new standards will be staggering to the drinking water industry.

Disinfection, which is critical to protect against microbial disease, produces chemical byproducts that may pose other health risks such as cancer. Trihalomethanes (THMs) are some of the types of disinfection byproducts (DBPs) that can be formed when chlorine and chloramines are used as disinfectants. Chlorine and chloramines have been the preferred disinfectants of choice because of lower costs and high effectiveness in controlling bacterial growth in the water distribution system.

THMs consist of four chemical compounds: chloroform, dibromochloromethane, bromodichloromethane, and bromoform. Currently, THMs are the only regulated DBPs. The current maximum contaminant level (MCL) for total THMs is 0.10 mg/L. However, new U.S. Environmental Protection Agency regulations, which will take effect in November 1998 and referred to as the Disinfectants-Disinfection Byproducts (D-DBP) Rule, will lower MCLs for total THMs and set new MCLs for other DBPs including bromate and the sum total concentration of five specified haloacetic acids (HAA5).<sup>1</sup> The new regulations will also require water utilities to remove DBP precursors (i.e., total organic carbon (TOC)) in addition to meeting the MCLs.

To meet the MCLs for THMs and HAA5, best available technologies that can be utilized include reducing DBP precursor concentrations prior to disinfection with chlorine or chloramines or ozone (i.e., enhanced coagulation or granular activated carbon (GAC) adsorption). To meet the bromate MCL, the BAT consists of controls on the ozonation process (ozone dose, pH), whereas lower concentrations of bromide and TOC in the raw water will also reduce bromate formation.

The new MCLs under the D-DBP Rule will be set in two stages. It is anticipated that the D-DBP Rule will be implemented according to the following table:<sup>2</sup>

**Current MCLs and Proposed MCLs Under the D-DBP Rule (mg/L)**

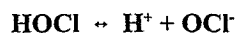
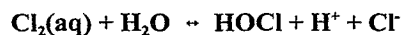
Disinfection Byproduct	Current MCLs	Stage 1 MCLs (November 1998)	Stage 2 MCLs (May 2002)
Total THMs	0.10	0.080	0.040
HAA5	None	0.060	0.030
Bromate	None	0.010	0.005

It is important to note that the proposed MCLs -- in particular Stage 1 -- are not based on human health criteria per se. The proposed Stage 1 MCLs for total THMs and HAA5 are based on technical and economic feasibility of achieving the MCLs with enhanced coagulation and chlorine for primary and secondary disinfection for approximately 90 percent of the surface-water systems. The proposed Stage 2 MCLs are currently placeholders based on what can be achieved with GAC adsorption and chlorine for primary and secondary disinfection for approximately 90 percent of the surface-water systems. The intent of the Stage 2 Rule, however, is for the MCLs to be more risk based. The final Stage 2 MCLs will be determined based on further research on the health effects of DBPs and treatment technologies for reducing DBP formation.

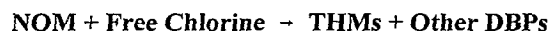
## **Disinfection Byproducts - Chemistry**

### **Chlorination**

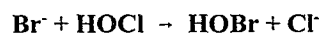
Free chlorination is the predominant method of disinfection in water treatment practice. THMs are one group of DBPs formed when natural organic matter (NOM) is halogenated by free chlorine. During disinfection, molecular chlorine reacts with water by the following reversible reactions:



The relative amounts of hypochlorous acid (HOCl) and hypochlorite (OCl<sup>-</sup>) produced in the above reactions are a function of pH. These chlorine species, known as free chlorine, are the disinfection agents in the chlorination process. Free chlorine (HOCl and OCl<sup>-</sup>) reacts with NOM to form THMs by the following general reaction:



If bromide is present in the water, it competes with free chlorine to form brominated THMs (dibromochloromethane, bromodichloromethane, and bromoform). The bromide is oxidized to hypobromous acid (HOBr) according to the following reaction:



Hypobromous acid then competes with free chlorine to produce THMs by the following general reaction:



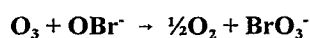
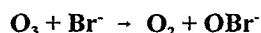
Because the atomic weight of bromine [79.91] is heavier than that of chlorine [35.45], the molecular weight of brominated THMs increase in proportion to the number of bromine atoms present in the THM compound: CHCl<sub>3</sub> [119.36], CHCl<sub>2</sub>Br [163.82], CHClBr<sub>2</sub> [208.28], and CHBr<sub>3</sub> [252.74]. As a result, bromide will increase the concentration of total THMs (on a weight basis) that is formed. In addition, because HOBr is a better halogenation agent than HOCl, bromide will also increase the concentration of total THMs on a molar basis (i.e., more THMs are formed). This can result in more frequent exceedances of the MCLs as the BATs do not remove bromide.

### **Ozonation**

Ozonation is increasingly being used for disinfection of drinking water supplies. The use of ozone as a disinfectant will reduce the potential for THM formation during disinfection. In addition, recent studies have shown that *Cryptosporidium* oocysts, a protozoan parasite that is resistant to inactivation by chlorine, may be inactivated by ozone. Further details on the need for greater disinfection due to resistant pathogenic organisms

will be presented in a later section entitled A Conflicting Need for Greater Disinfection of Drinking Water.

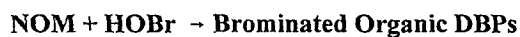
In the presence of bromide, oxidation by ozone will lead to the formation of hypobromite ( $\text{OBr}^-$ ). Further oxidation of hypobromite leads to the formation of bromate ( $\text{BrO}_3^-$ ):



The amount of hypobromite available for oxidation to bromate is dependent on pH, based on the relative amounts of hypobromous acid and hypobromite:



In addition, hypobromous acid may react with NOM to form brominated organic DBPs (e.g., bromoform, dibromoacetic acid, and monobromoacetic acid):



An increase in pH will result in an increase in bromate formation. Bromate formation will also be increased when bromide concentrations in the water supply are increased.

### DBP Precursors - Removal Requirements

Bromide and NOM are the major precursors that must be controlled. Stage 1 of the D-DBP Rule will require reducing the TOC concentration in water supplies. TOC removal requirements are based on the source water TOC and alkalinity. A specified percentage of the TOC in the source water will need to be removed:

**Proposed TOC Removal Requirements Under the D-DBP Rule<sup>2,3</sup>**

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L)		
	0 - 60	> 60 - 120	> 120
> 2 - 4	35%	25%	15%
> 4 - 8	45%	35%	25%
> 8	50%	40%	30%

Water pumped from the Delta to southern California typically contains 3-7 mg/L of TOC, with alkalinity ranging from 40 to 120 mg/L.<sup>4,5</sup> As a result, municipalities using Delta water as a source of drinking water will need to remove 25 to 45 percent of TOC in the source water. In addition, this TOC removal requirement is scheduled to be in effect in November 1998.

While enhanced coagulation or granular activated carbon adsorption will be required to reduce total organic carbon levels in source waters, these treatment technologies are not effective in lowering bromide levels. The most effective way to prevent the formation of brominated DBPs is to reduce the presence of bromide in the source water. As a result, the new drinking water standards under the D-DBP Rule will place a greater need on providing water from sources with low bromide levels.

## Human Health Impacts of DBPs

The primary human health concern for THMs, haloacetic acids (HAAs), and bromate has historically been the potential carcinogenicity to humans of the chemical compounds. Several animal studies have documented the carcinogenicity of bromodichloromethane, bromoform, dichloroacetic acid and bromine containing HAAs, and bromate. Chloroform has been demonstrated to not be carcinogenic. Instead, it is cytotoxic and causes health effects at high doses. The USEPA recently reclassified chloroform and raised its maximum contaminant level goal to 300  $\mu\text{g/L}$ .<sup>22</sup> The carcinogenicity of dibromochloromethane has not yet been well established. However, in establishing a maximum contaminant level goal for dibromochloromethane, the USEPA accounted for the possible carcinogenicity to humans by incorporating an additional safety factor of 10 to the reference dose (RfD) for dibromochloromethane. The RfD was derived from liver toxicity data in subchronic studies in rats. The following table summarizes the current information on the carcinogenicity of DBPs:

**Carcinogenicity of DBPs**

Disinfection Byproduct	Carcinogenic Potency Factor (mg/kg/day) <sup>1</sup>	Maximum Contaminant Level Goal ( $\mu\text{g/L}$ )	USEPA Carcinogen Classification	Theoretical Excess Cancer Risk Level ( $\mu\text{g/L}$ ) (1)		
				$1 \times 10^{-4}$	$1 \times 10^{-5}$	$1 \times 10^{-6}$
$\text{CHCl}_3$	NA	300	NA	-	-	-
$\text{CHCl}_2\text{Br}$	$6.2 \times 10^{-2}$ (kidney tumors in male rats)	0	Group B2 (Probable Human Carcinogen)	0.6	6	60
$\text{CHClBr}_2$	RfD (2)	60	Group C (Possible Human Carcinogen)	-	-	-
$\text{CHBr}_3$	$7.9 \times 10^{-3}$ (neoplastic lesions in large intestines of female rats)	0	Group B2 (Probable Human Carcinogen)	4	40	400
$\text{BrO}_3^-$	$\sim 7 \times 10^{-1}$ (3) (renal tumors in rats)	0	Group B2 (Probable Human Carcinogen)	0.05	0.5	5

(1) Assumes average human body weight of 70 kg and daily consumption of 2 liters of drinking water.

(2) Based on RfD of 0.02 mg/kg/day (liver toxicity, subchronic, rats) plus an additional safety factor of 10 for possible carcinogenicity and a relative source contribution of 80%.

(3) Estimated from Theoretical Excess Cancer Risk Level. No Carcinogenic Potency Factor published in Integrated Risk Information System.

Of the THM compounds, bromodichloromethane is the most potent as a carcinogen with a carcinogenic potency factor of  $6.2 \times 10^{-2}$ . The carcinogenic potency of bromodichloromethane is approximately ten times that for bromoform. Furthermore, the carcinogenic potency of bromate is approximately ten times that of bromodichloromethane.

In addition to the animal toxicity studies, numerous epidemiology studies have been conducted to determine if there were any associations between chlorination or chloramination of drinking water with the risk of cancer and adverse reproductive effects in humans. Since the 1974 discovery of THMs (which included chloroform, a known animal carcinogen at that time) being formed as byproducts when surface waters were disinfected with chlorine, several studies were conducted to find an association between chlorinated drinking water and cancer mortality. The results of these studies have suggested associations with a wide range of cancer sites, including gall bladder, esophagus, kidney, breast, liver, pancreas, prostate, stomach, bladder, colon, and rectum. The most suggestive associations were with bladder cancer. However, interpretation of these studies

were hampered by a lack of control for confounding variables (e.g., age, sex, individual health, smoking history, and other exposures).

Several epidemiology studies were conducted to determine associations between various water quality components of drinking water (including THM levels) and various reproductive or developmental endpoints.

One study conducted in Iowa in 1992 compared water supplies containing chloroform and other THMs with low birthweight, prematurity, and intrauterine growth retardation. The results of this study suggested an increased risk for intrauterine growth retardation in communities where chloroform levels exceeded 0.010 mg/L. Prematurity was not associated with chloroform exposure, and the risk for low birthweight was only slightly increased. The authors considered the results of this study to be preliminary. Accordingly, the results should be interpreted with caution.

Another study was conducted in Massachusetts in 1993 to determine the relationship between community drinking water quality and a wide range of adverse pregnancy outcomes, including congenital anomalies, stillbirths, and neonatal deaths. A higher frequency of stillbirths was correlated with chlorination and detectable lead levels; cardiovascular defects were associated with lead levels; central nervous system (CNS) defects were associated with potassium levels; and face, ear, and neck anomalies were associated with silver levels. The authors indicated that the findings of this study must be considered as preliminary because of the problems and limitations of the exposure assessment.

The New Jersey Department of Health conducted a cross-sectional study and a case-control study in 1992 to evaluate the association of drinking water contaminants with birth weight and selected birth defects. The cross-sectional study base included 81,055 live births and 599 single fetal deaths between January 1985 and December 1988. The case-control study included interviews with 593 mothers. The results of the studies showed significant elevations in the odds ratio (or relative risk) for several adverse reproductive outcomes:

**New Jersey Department of Health Studies (1992) - Odds Ratios**

<b>Adverse Reproductive Outcome</b>	<b>Epidemiology Study Type</b>	<b>THM Levels (mg/L)</b>	<b>Odds Ratio (Relative Risk)</b>
Low term birth weight	Cross-Sectional	> 0.080	1.34
Birth defects (overall)	Cross-Sectional	> 0.080	1.53
CNS defects	Cross-Sectional	> 0.080	2.6
Neural tube defects	Cross-Sectional	> 0.080	2.98
Cardiac defects	Cross-Sectional	> 0.080	1.44
Neural tube defects	Case-Control	> 0.080	4.25
Cardiac defects	Case-Control	> 0.015	2.0

The authors of this study indicated that the findings should be interpreted with caution because of possible exposure misclassification, unmeasured confounding, and associations which could be due to chance occurrences.

Most recently, the California Department of Health Services (DHS) completed an epidemiology study investigating the relationship between THMs in drinking water and spontaneous abortion. This study was published in the March 1998 edition of *Epidemiology*.<sup>6</sup> In addition, news articles highlighting this study also appeared in the press. The results of this study suggest that pregnant women who drank five or more glasses per day of cold tap water containing  $\geq 0.075$  mg/L of total THMs were at higher risk of spontaneous abortion. Furthermore, of the four THM compounds, only bromodichloromethane at levels of  $\geq 0.018$  mg/L was found to be associated with spontaneous abortion. The results of this study may add further weight to the toxicological properties of bromodichloromethane as the primary THM compound of concern. Representatives of DHS recently presented a summary of this study at a recent meeting of the CALFED Water Quality Technical Group. The authors of the study pointed out that no cause-effect relationship could be established with epidemiology studies, and stated that the study needed to be repeated elsewhere in the country to add validation to its findings.

The USEPA convened an expert panel to review the epidemiological evidence for an association between DBPs and adverse reproductive/developmental health effects. The DHS study was found to be well done and the first to demonstrate an association with a bromine-containing DBP. Moreover, toxicological studies on fetal loss have shown bromodichloromethane to be approximately 10 times more toxic than volatile organic contaminants such as trichloroethane.

The approach to establishing lower MCLs for total THMs has been based on theoretical excess cancer risk levels to the general population. Because carcinogenicity is considered a toxicological endpoint from chronic use, compliance with the MCLs has been based on the running annual average of quarterly total THM measurements. However, EPA is considering establishing MCLs for the individual THM compounds, with consideration for toxicological effects other than carcinogenicity, including developmental and reproductive toxicity. Consideration of these "more acute" noncarcinogenic effects will require compliance with the new MCLs to be at all locations and at all times (i.e., no annual averaging of distribution system samples). The DHS study may serve to strengthen EPA's push in this direction, especially since the study suggests that an increased risk for spontaneous abortion to pregnant women already exists at total THM levels below the currently proposed lower MCL of Stage 1 of the D-DBP Rule.

### **Bromide in the Sacramento-San Joaquin Delta**

The study of DBP precursors and their sources is important for determining how DBP formation might be controlled. The two major precursors are NOM and bromide. In the southern Delta, where water is diverted by the State Water Project, Central Valley project, and Contra Costa Water District, concentrations of NOM and bromide are higher than in the waters of the northern Delta.

The Delta has one major source of bromide. The major source is sea water that enters the western Delta from tidal excursions and mixes with Sacramento River water flowing through the Delta to the export facilities in the southern Delta. The bromide in the water at Clifton Court Forebay and at the Contra Costa Water District intake are attributed to sea water intrusion. Another source of bromide may be the San Joaquin River. However, the primary source of bromide in the San Joaquin River is probably from agricultural return water which contains bromide and is exported from the Delta, so this may simply be a "recycling" of bromide from sea water intrusion. Another source of bromide is connate water beneath some Delta islands (e.g., Empire Tract).<sup>4</sup> However, on a mass balance basis, this source contributes very little to the bromide in exported waters.

Overall, the primary source of bromide in Delta waters is a result of sea water intrusion.<sup>5</sup> The Department of Water Resources and Metropolitan Water District of Southern California have conducted studies to evaluate sea water intrusion in the Delta.

Because of the stoichiometric relationship between Cl and Br in sea water, Br levels can be



predicted based on measured  $\text{Cl}^-$  levels (provided that no other confounding sources of  $\text{Br}^-$  and  $\text{Cl}^-$  are present). The concentration of  $\text{Cl}^-$  and  $\text{Br}^-$  in sea water is 18,980 and 65 mg/L, respectively. If  $\text{Br}^-$  and  $\text{Cl}^-$  in Delta water were only from sea water diluted with unsalty fresh water, then the following equation could be used to predict  $\text{Br}^-$  levels, given a measured  $\text{Cl}^-$  level:

$$\text{Br}^- = 0.00342 \times \text{Cl}^-$$

MWD empirically developed a  $\text{Br}^-$  to  $\text{Cl}^-$  relationship in State Water Project water, based on data collected from 1987 through 1989:

$$\text{Br}^- = 0.00289 \times \text{Cl}^- + 0.00671$$

These limited data suggested that most of the  $\text{Cl}^-$  and  $\text{Br}^-$  present in Delta water could be explained by sea water intrusion.

In 1990-1991, DWR and MWD conducted a bromide intrusion study to evaluate the effect of the ongoing drought on increased salinity in the Delta.<sup>7,8,9</sup> During August 1990 through January 1991,  $\text{Br}^-$  levels in Delta outflow increased from 0.27 to 0.61 mg/L. At the Mallard Island sampling site, where the Sacramento River enters the bay that ultimately leads to the San Francisco Bay,  $\text{Br}^-$  ranged from 6.6 to 17.7 mg/L. At this estuary location, approximately 9 to 27 percent of the water was sea water. Using linear regression, the following relationship was obtained from this study:

$$\text{Br}^- = 0.00327 \times \text{Cl}^- + 0.00496$$

This equation, which falls between the pure sea water relationship and the relationship derived by MWD for SWP water, confirms that sea water is by far the major source of salinity in the Delta.

Based on a nationwide survey conducted in 1991-1993 by Gary L. Amy of the University of Colorado, bromide levels in waters of the Delta are typically in the 90<sup>th</sup> to 95<sup>th</sup> percentile of levels found nationwide.<sup>5,10</sup> This means that 90 to 95 percent of the nation's drinking water sources have bromide levels lower than levels typically found in the Delta.

The high levels of bromide found in Delta waters have both economic and public health significance in relation to the new U.S. EPA drinking water regulations soon to be in effect. The BATs required under the D-DBP Rule were established by EPA based on the ability of 90 percent of the nation's water treatment systems to meet the lower MCLs using the BATs. Water treatment systems with current sources of poorer water quality and which can not meet the MCLs may need to utilize more expensive treatment technologies or provide drinking water from sources with lower levels of bromide.

Sacramento River water above the Delta typically contains 1-2 mg/L of total organic carbon and  $\leq 0.02$  mg/L of bromide. However, water pumped from the Delta to southern California typically contains 3-7 mg/L of TOC and 0.1-0.5 mg/L of bromide. This degradation in water quality, which results in increases in TOC and bromide, presents users of Delta water with tremendous challenges in meeting the new drinking water standards and regulatory requirements.

### Current Bromide Data for Delta Channels and Agricultural Drains

During Water Years 1996 and 1997, data on bromide concentrations in six Delta agricultural drains were collected through DWR's Municipal Water Quality Investigations Program.<sup>11,12</sup> With the exception of Empire Tract, bromide that is found in agricultural drains is simply what is present in the irrigation water after concentration from evaporation. Table 1 shows the bromide data for agricultural drains located on Bacon Island, Staten Island, Venice Island, Jersey Island, Pescadero Tract, and Twitchell Island. The data for the six islands were separated into two groups based on a 1954-1955 study conducted by DWR on Delta agricultural drainage volumes.<sup>13,14</sup> In this study, it was found that the collective agricultural drainage from Staten Island, Bouldin Island, Venice Island, Empire Tract, King Island, Terminous Tract, Bacon Island, Mandeville Island, McDonald Tract, Mildred Island, and Medford Island contributed approximately 46.5 percent of total Delta drainage during June through August, and approximately 32.5 percent of total Delta drainage during September through May. As a result, monthly averages of bromide data for agricultural drains on Bacon Island, Staten Island, and Venice Island were computed as one group, while monthly averages of bromide data for Jersey Island, Pescadero Tract, and Twitchell Island were computed as another group. The monthly average bromide concentrations for the two groups, as well as the monthly bromide concentrations for the Bacon Island agricultural drain, are shown in the following figure:

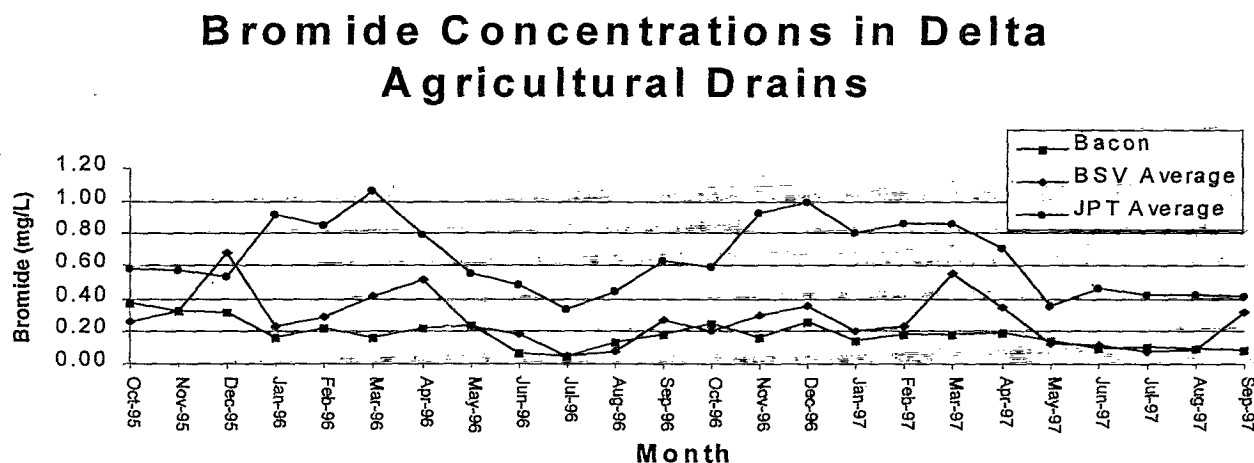
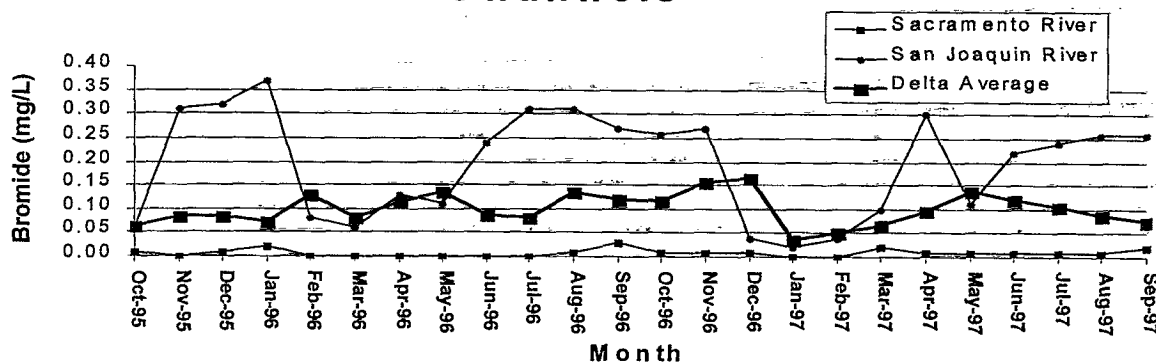


Table 2 shows the data for bromide concentrations in Delta channels, including bromide data for the Sacramento River, San Joaquin River, and Sacramento River at Mallard Island. The monthly averages of bromide concentrations in Old River, Middle River, DMC Intake, and H.O. Banks were used to represent the monthly Delta average bromide concentrations. In general, bromide concentrations in the Sacramento River, if detected, were very low (average: 0.01 mg/L); while bromide concentrations in the San Joaquin River ranged from 0.02 to 0.37 mg/L (average: 0.20 mg/L). The monthly bromide concentrations for the Sacramento River and San Joaquin River, and the monthly Delta average bromide concentrations, are shown in the following figure:

## Bromide Concentrations in Delta Channels



A comparison of total agricultural drainage volumes and tributary inflows into the Delta can provide some information on the relative impacts of each source on bromide concentrations in the Delta. The following figure and Table 3 show estimates of total Delta agricultural drain volumes obtained from the 1954-1955 study:

## 1954 - 1955 Estimated Monthly Total Delta Lowland Drainage

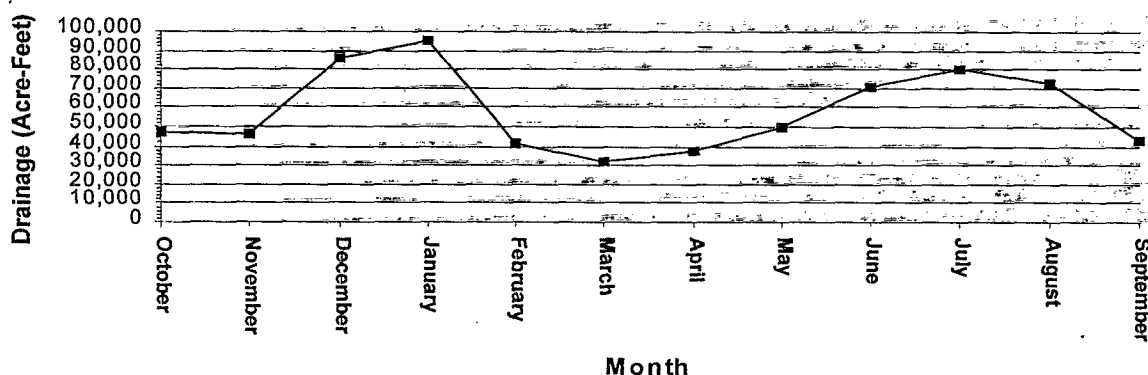


Table 4 shows Delta inflows, outflows, and exports obtained from DAYFLOW. Table 5 compares total Delta agricultural drainage volumes with total Delta inflows, Sacramento River inflows, and San Joaquin River inflows. During Water Years 1996 and 1997, total Delta agricultural drainage volumes were small relative to total Delta inflows (0.56% - 6.23%) and Sacramento River inflows (0.94% - 7.86%). Drainage volumes can be very significant when compared to San Joaquin River inflows (up to 64.12%), which is a result of the much smaller inflows from the San Joaquin River. However, the much smaller inflow of water from the San Joaquin River implies that it is not a major source of bromide in the Delta.

Because of the effect of sea water intrusion in the Delta, it is currently not possible to accurately predict bromide concentrations in Delta channels without the use of complex models, such as the DSM2 model developed by DWR's Delta Modeling Section. The DSM2 model was developed to predict the transport of DBP precursors in the Delta. The model can be used to simulate the hydrodynamics of the Delta (tidal stages, riverine inflows, and agricultural returns), and the transport of organic precursors (using surrogates such as

THM formation potential carbon, dissolved organic carbon, and/or ultraviolet absorbance at 254 nm) and bromide (using surrogates such as total dissolved solids, electrical or specific conductivity, and/or chloride). The DSM2 model, as well as other models developed by DWR's Delta Modeling Section, will be used in modeling Delta alternatives to improve drinking water quality. In January 1998, staff of DWR's Municipal Water Quality Investigations Program presented a plan to identify the best solutions for protecting and improving the drinking water quality of the Delta using models developed by DWR. The modeling work proposed in this plan is scheduled to be completed over a period of two and one-half years. A copy of the MWQI plan for modeling Delta alternatives is included as an appendix.

The effect of sea water intrusion was much less during Water Years 1996 and 1997 (wet years) than during the 1990-1991 (dry years) study conducted by DWR and MWD. This lesser effect can be observed by comparing the bromide concentrations measured at the Mallard Island sampling site during the two different time periods. Bromide concentrations at this sampling site during 1996-1997 ranged from 0.03 to 12.10 mg/L. This range of concentrations was much lower than the range of 6.6 to 17.7 mg/L, which was measured during the drought years of 1990-1991. Accordingly, during Water Years 1996 and 1997, the Delta average concentrations ranged from 0.04 to 0.17 mg/L (with the highest Delta concentration of 0.24 mg/L measured at DMC Intake in August 1996). This range of Delta concentrations was much lower than the range of 0.27 to 0.61 mg/L measured during 1990-1991. Because drinking water regulations must be met year round (wet or dry years), utilities treating Delta water need to install technology to meet the MCLs even during dry years, which pose the greatest challenge. Moreover, if additional studies confirm that certain bromine-containing DBPs can cause adverse reproductive/developmental effects, new MCLs may need to be met at all times during the year.

#### **DBP Formation of Sacramento-San Joaquin Delta Water**

To evaluate the effect of TOC and bromide on the formation of DBPs in Delta waters, Stuart Krasner of MWD performed simulation distribution system (SDS) tests for THMs on 25 different combinations of TOC and Br<sup>-</sup> (a five-by-five matrix) using agricultural drainage from a high-TOC agricultural drain diluted with water from the Sacramento River above the City of Sacramento, with appropriate Br<sup>-</sup> spikes.<sup>5</sup> These simulation tests were conducted to simulate the levels of THMs or bromate which may occur when Delta water, used as a source of drinking water, is chlorinated or ozonated for disinfection.

To ensure that these "synthetic" samples could be used to represent differing water qualities of Delta water, a preliminary test was conducted to compare a sample from H.O. Banks with a "synthetic" sample consisting of 90% Sacramento River water and 10% agricultural drainage, with an appropriate Br<sup>-</sup> spike. The "synthetic" sample matched the H.O. Banks sample in TOC, UVA, and Br<sup>-</sup> levels, and similar amounts of individual and total THMs were produced:

Parameter	H.O. Banks Sample	"Synthetic" Sample
TOC (mg/L)	3.65	3.53
UVA (cm <sup>-1</sup> )	0.122	0.126
Br <sup>-</sup> (mg/L)	0.48	0.48
3-hour SDS THM (mg/L)		
Chloroform	0.012	0.013
Bromodichloromethane	0.034	0.036
Dibromochloromethane	0.067	0.070
Bromoform	0.037	0.038
Total THMs	0.150	0.157
24-hour SDS THM (mg/L)		
Chloroform	0.034	0.034
Bromodichloromethane	0.065	0.073
Dibromochloromethane	0.102	0.117
Bromoform	0.036	0.040
Total THMs	0.237	0.263

Because Sacramento River water and H.O. Banks represent two extremes, the five-by-five matrix of "synthetic" samples was used to address all possible combinations of TOC and Br<sup>-</sup> that might be experienced with alternative Delta transfer facilities. The conditions of the SDS tests included an incubation temperature of 25°C, a pH of 8.2, a target chlorine residual of 0.5 - 1.5 mg/L, and an incubation time of 3 hours. The 3-hour incubation time was used to represent a 3-hour prechlorination scenario. If postchloramination is used, Delta water could barely meet the Stage 1 MCL of 0.080 mg/L for total THMs with up to 4 mg/L TOC, if Br<sup>-</sup> were not present. As Br<sup>-</sup> increases, however, the range of TOC levels that would enable compliance with the 0.080 mg/L standard for total THMs shrinks, even with enhanced coagulation (which removes TOC, but not Br<sup>-</sup>). To reliably meet the MCL, a system would need to produce DBPs at a level less than or equal to 80 percent of the MCL (i.e.,  $\leq 64 \mu\text{g/L}$  of total THMs for Stage 1). This would limit one to a TOC of 3.2 mg/L and no bromide, or 2.0 mg/L TOC and 0.1 mg/L bromide, etc. The results indicate that both TOC and Br<sup>-</sup> in Delta water must be controlled to meet the lower MCL for total THMs:

**SDS THM Results (Five-By-Five Matrix) - mg/L**

Bromide (mg/L)	Total Organic Carbon (mg/L)				
	1.10	1.36	1.98	3.25	4.15
≤ 0.01	0.024	0.031	0.038	0.064	0.078
0.1	0.043	0.051	0.060	0.080	0.091
0.2	0.060	0.075	0.083	0.103	0.113
0.4	0.075	0.113	0.128	0.142	0.159
0.8	0.088	0.137	0.182	0.241	0.243

Ozonation of Delta waters, followed by chloramination, presents another option for compliance with standards for total THMs. To evaluate the effect of TOC and Br<sup>-</sup> on the formation of bromate resulting from ozonation of Delta waters, a simulation test for ozonation using a similar five-by-five matrix was conducted. The conditions of the ozone simulation tests included ambient pH of approximately 8, temperature of 20°C, and a target ozone residual of 0.35 ± 0.05 mg/L. To achieve the target ozone residual, an ozone-to-TOC ratio of approximately 2 mg/mg (i.e., 2 milligrams of ozone per milligram of TOC) was utilized. Under these conditions, the results indicated that Delta water with 1.6 mg/L TOC and 0.1 mg/L Br<sup>-</sup> may be capable of achieving the Stage 1 bromate MCL of 10 µg/L, whereas an increase in either TOC or Br<sup>-</sup> may yield a bromate level exceeding the MCL:

**Bromate Formation Results (Five-By-Five Matrix) - µg/L**

Bromide (mg/L)	Total Organic Carbon (mg/L)				
	1.2	1.6	2.2	2.9	3.7
≤ 0.01	<3	<3	4	<3	7
0.1	6	7	11	12	19
0.2	11	12	19	25	27
0.4 - 0.5	25	23	36	39	49
0.7 - 0.9	29	40	53	57	65

However, these experiments were based on inactivating *Giardia*, not *Cryptosporidium*. Higher ozone dosages are required for *Cryptosporidium* inactivation. Nonetheless, these results show that both TOC – which increases ozone demand – and bromide resulted in increases in bromate formation.

Reducing the pH of water before ozonation can reduce the formation of bromate during disinfection. Several studies have shown that bromate concentrations produced during ozonation will increase with an increase in pH.<sup>21</sup> Stuart Krasner showed that decreasing the pH from 8 to 6 lowered the ozone dosage required for disinfection by 33 percent for a source water containing a TOC of 3.5 mg/L. The major constraint to using pH adjustment as the BAT for minimizing bromate formation is the cost of acid for high-alkalinity waters, and the subsequent need to adjust pH after treatment for corrosion control. Stuart Krasner indicated that treating State Water Project water at an average flow of 520 million gallons per day could potentially reduce the ozone dose for minimum disinfection from 1.7 to 1.0 mg/L, resulting in an ozone cost savings of approximately \$0.8 million per year. The estimated chemical costs, however, would be approximately \$4 million and \$2 million per year, respectively, for the acid to reduce the pH from 8 to 6 and the caustic to raise the pH back to 8 prior to distribution.

## A Conflicting Need for Greater Disinfection of Drinking Water

Disease-causing organisms may exist even in pristine waters. Protozoans are microscopic organisms; some types of protozoans live in the bodies of warm-blooded animals and can cause disease in humans who drink water shared with these animals. *Giardia lamblia* is common in mountain-dwelling mammals. Giardiasis is a disease in humans which comes from this organism. *Cryptosporidium* is another pathogenic organism found in drinking water supplies as a result of contamination by mammals.

*Cryptosporidium* outbreaks have been documented in many places throughout the world. The following table lists some of the most significant outbreaks documented in the recent past:

**Significant *Cryptosporidium* Outbreaks**

Year	Location	Approximate Number of Reported Cases
1984	Braun Station, Texas	2,000 cases
1987	Carrollton, Georgia	13,000 cases
1989	Thames River area, England	100,000 cases
1992	Jackson County, Oregon	15,000 cases
1993	Milwaukee, Wisconsin	403,000 cases, 100 deaths
1994	Las Vegas, Nevada	78 cases, 16 deaths

In April 1993, approximately 403,000 persons in Milwaukee, Wisconsin became ill of cryptosporidiosis, the disease resulting from the presence of *Cryptosporidium* in their water supply. Approximately 100 deaths resulted from this outbreak. The suspected sources of *Cryptosporidium* were cattle wastes, slaughterhouse wastes, and sewage carried by rivers tributary to Lake Michigan, the water body used as the source of drinking water. This outbreak was associated with operational deficiencies in the water treatment plant resulting in high fluctuations in turbidity, and presents a striking example of the importance of maintaining the quality of source waters.

More significantly, the *Cryptosporidium* outbreak in Las Vegas, Nevada in May 1994 was the first documented epidemiologically confirmed waterborne outbreak from a water system with no associated treatment deficiencies or breakdowns. During this outbreak, 78 immunocompromised persons became ill of cryptosporidiosis, even when no *Cryptosporidium* was detected in the finished drinking water. This outbreak clearly suggests that *Cryptosporidium* is a potential health threat in all drinking water systems, particularly to immunocompromised persons. As a result, Las Vegas is retrofitting their plant with ozone. However, studies at Las Vegas in Colorado River water with approximately 80  $\mu\text{g/L}$  of bromide have shown the potential for a significant amount of bromate formation when ozone is applied at doses sufficient to inactivate *Cryptosporidium*.

In addition to *Giardia* and *Cryptosporidium*, there are many other disease-causing viruses, bacteria, and protozoans which are of concern. The following table lists some of the waterborne diseases of concern in the United States:

### Some Waterborne Diseases of Concern in the United States<sup>16</sup>

Disease	Microbial Agent	General Symptoms
Amebiasis	Protozoan ( <i>Entamoeba histolytica</i> )	Abdominal discomfort, fatigue, diarrhea, flatulence, weight loss
Campylobacteriosis	Bacterium ( <i>Campylobacter jejuni</i> )	Fever, abdominal pain, diarrhea
Cholera	Bacterium ( <i>Vibrio cholerae</i> )	Watery diarrhea, vomiting, occasional muscle cramps
Cryptosporidiosis	Protozoan ( <i>Cryptosporidium parvum</i> )	Diarrhea, abdominal discomfort
Giardiasis	Protozoan ( <i>Giardia lamblia</i> )	Diarrhea, abdominal discomfort
Hepatitis	Virus (hepatitis A)	Fever, chills, abdominal discomfort, jaundice, dark urine
Shigellosis	Bacterium ( <i>Shigella</i> species)	Fever, diarrhea, bloody stool
Typhoid Fever	Bacterium ( <i>Salmonella typhi</i> )	Fever, headache, constipation, appetite loss, nausea, diarrhea, vomiting, appearance of an abdominal rash
Viral Gastroenteritis	Viruses (Norwalk, rotavirus, and other types)	Fever, headache, gastrointestinal discomfort, vomiting, diarrhea

In response to the 1993 *Cryptosporidium* outbreak in Milwaukee, EPA proposed to amend the current Surface Water Treatment Rule to provide additional protection against disease-causing organisms in drinking water.<sup>17</sup> The proposed Enhanced Surface Water Treatment Rule would require more rigorous disinfection, including filtration and high level disinfection, or both, to inactivate or remove viruses and protozoan cysts and oocysts such as *Giardia* and *Cryptosporidium*. Conversely, however, the D-DBP Rule places constraints on the formation of DBPs.

Results of studies have shown that *Giardia* cysts can be inactivated by high levels of chlorine, and that *Cryptosporidium* oocysts are resistant to chlorine. More recent studies have shown that *Cryptosporidium* oocysts may be inactivated by ozone.<sup>18</sup> However, the levels of inactivation efficiencies achieved in the studies varied depending on the design of the experiments.

The MCLG for both *Giardia* cysts and *Cryptosporidium* oocysts in drinking water is zero. As a result, removal/inactivation rates for these pathogenic organisms is dependent on the densities of these organisms found in the source water. To achieve levels of less than one cyst or oocyst per 100 liters in drinking water, removal rates must be increased logarithmically according to the following table:



### Giardia Cysts and Cryptosporidium Oocysts Removal/Inactivation Rates<sup>17</sup>

Number of Giardia cysts or Cryptosporidium oocysts per 100 liters in the Source Water	Required Removal/Inactivation Level to Achieve <1 Cyst or Oocyst per 100 liters in Drinking Water (%)	Log Removal Level
<1	99.9	3
1-9	99.99	4
10-99	99.999	5
>99	99.9999	6

To ensure that sound regulatory and public health decisions are made, the Information Collection Rule was promulgated in 1996 so that EPA can obtain the necessary technical and scientific information needed to assess the risk-risk tradeoff posed by simultaneous control of disinfection by-products and pathogenic organisms in drinking water.<sup>19</sup> The Information Collection Rule requires all large public water systems, over an 18-month period, to collect and report data on the occurrence of DBPs and pathogenic organisms (including bacteria, viruses, *Giardia*, and *Cryptosporidium*) in drinking water. With this information, an assessment of the extent and severity of risk and the potential for health problems due to the presence of DBPs and pathogenic organisms in drinking water will be made. Based on this assessment, EPA will then determine the need to revise current drinking water filtration and disinfection requirements and the need for more stringent regulations for disinfectants and DBPs.

### **Determining Bay Delta Drinking Water Quality Criteria**

Finally, in December 1996, the California Urban Water Agencies (CUWA) released a draft report entitled Bay Delta Drinking Water Quality Criteria.<sup>20</sup> This draft report was developed by an expert panel consisting of three water quality and treatment specialists who have specific expertise in the formation of DBPs. The draft report concluded that for currently available advanced water treatment technology to be able to meet probable future drinking water quality standards with water diverted from the Delta, the source water quality should have concentrations less than 3.0 mg/L for TOC and less than 0.05 mg/L for bromide. It was the opinion of the expert panel that these concentrations would be necessary to allow users the flexibility to incorporate either of the technologies evaluated to meet the currently proposed Stage 2 MCLs of the D-DBP Rule. The two technologies evaluated were:

- 1) the use of 40mg/L of alum at a pH of 7.0 and possibly as low as 6.5 in the coagulation process, followed by chlorine disinfection with a chloramine residual in the distribution system; and
- 2) the use of ozone at specific ozone:TOC ratios followed by a chloramine residual.

The chlorine and ozone disinfection criteria were proposed to meet potential 1 or 2 log *Giardia* inactivation requirements. Only the ozone disinfection strategy was considered to provide potential 1 log *Cryptosporidium* inactivation. The TOC value of < 3.0 mg/L is constrained by the formation of total THMs when using enhanced coagulation for TOC removal and free chlorine to inactivate *Giardia*. The bromide value of < 0.05 mg/L is constrained by the formation of bromate when using ozone to inactivate *Cryptosporidium*.

## Conclusion

New information on the human health impacts and toxicological properties of brominated DBPs will have a significant impact on the development of new drinking water standards under the D-DBP Rule. The final Stage 2 MCLs under the D-DBP Rule will be determined based on further research on the health effects of DBPs and treatment technologies for reducing DBP formation. BATs which will be required to reduce DBP precursors in source waters are not effective in lowering bromide levels. As a result, the new drinking water standards will place a greater need on providing water from sources with low bromide levels.

High TOC concentrations in Delta waters already pose a tremendous challenge to municipalities when Delta water is used as a drinking water source. The typically high TOC concentrations in Delta waters increase the potential for high levels of THMs to be formed during disinfection, and will require higher levels of TOC removal prior to disinfection. High bromide levels in Delta waters exacerbate this problem of DBP formation. The presence of bromide increases the formation of THMs during disinfection of Delta waters. In addition, new information relating to the toxicological properties and health effects of brominated DBPs (especially bromodichloromethane) may lead to much more stringent drinking water standards. The economic and public health impacts resulting from these lower standards when Delta water is used as a drinking water source may be severe.

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# Tables

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Table 3

**1954 - 1955 Estimated Monthly  
Total Delta Lowland Drainage**

Month	Drainage (Acre-Feet)
October	46,817
November	46,537
December	85,731
January	95,668
February	41,960
March	32,419
April	37,628
May	49,813
June	71,084
July	80,606
August	72,170
September	43,116
<b>Total</b>	<b>703,549</b>

# MODELING DELTA ALTERNATIVES TO IMPROVE DRINKING WATER QUALITY

by  
Marvin Jung

**Presented at MWQI Advisory Committee meeting of January 13, 1998**

This is an outline of goals, tasks, and products that we plan to complete over the next two and one-half years with respect to identifying the best solutions for protecting and improving the drinking water quality of the delta.

We will review the historical drinking water quality of the delta to develop sets of input data for the Delta Water Treatment and Costs Model developed under the DWR/ Malcolm-Pirnie contract. We will test different scenarios of actions within the delta including the original set of 12+ proposed CalFed alternatives that might improve water quality and treatment. The scenarios include the following actions and in combination with each other:

1. reducing agricultural drainage volume by:
  - a. conversion to fallow land
  - b. conversion to flooded wetlands for soil subsidence control
2. reducing TOC concentrations in agricultural drainage by:
  - a. treating drainwater by chemical flocculation prior to discharge
  - b. reducing leaching frequency
3. relocating or adding intake and water storage sites
  - a. out of delta storage
  - b. in delta storage
4. blending water
5. shortening water residence time in the delta
  - a. wider channels to increase flow
  - b. deep flooded islands to increase flow and provide storage
  - c. a separate canal

Technical briefings or workshops will be made before the MWQI Advisory Group as the work proceeds to each milestone. The Advisory Group will contribute to the program by providing guidance, suggestions, and review of the tasks. A series of technical summary reports will be prepared as consultant's reports to DWR. This will enable faster distribution of information to the MWQI Advisory Group. These reports, in turn, will be edited to become official DWR publications.

The following work plan describes the goals and products of modeling alternatives to improve the drinking water quality of delta water supplies. The tasks are grouped into three topics that were common themes in the original set of proposed CALFED list of delta alternatives. The topics for study are: (1) drainage control options, (2) designing wetlands and shallow water storage options, and (3) water supply intake options. These three topics will be studied concurrently. The results of the work will be used to prepare an Alternatives Assessment Report in 1999-2000.

## **Tasks**

### **1. EXAMINING DRAINAGE CONTROL OPTIONS**

#### **Goal: Estimating Monthly DOC Loads from Delta Island Drainage**

***Proposed Report: Delta Island Drainage Estimates, 1954-55 vs. 1995***

***Completion Date: 1/15/98***

We are comparing the 1995 and 1996 delta island drainage volume estimates computed by USGS for DWR in the Delta Island Water Use Study to the 1954-55 estimates in DWR Report Number 4 (1956). We are comparing the methodologies used, seasonal trends in estimated drainage volumes discharged, land use changes, computational assumptions, and water year hydrologies (e.g., rainfall). We will determine if there are significant differences between the annual and monthly estimates for the entire delta and subregions.

A report titled "Delta Island Drainage Estimates, 1954-55 vs. 1995" will be prepared and available in mid-January 1998.

We will confer with the Delta Modeling Group on our analysis. Depending upon the results of our report, we may recommend a range of values to use for monthly drainage volume discharges rather than a single value such as an average. It is probable that there will be more than one set of monthly drainage volume numbers that will be recommended for use in the delta water quality and hydrology models.

#### **Goal: Developing Drainage Reduction Options**

***Proposed Report: Candidate Region in the Delta for Reduction of Organic Carbon Loads***

***Completion Date: 4/1/98***

We will develop a set of island drainage reduction options. Organic carbon mass loads will be computed from drainage volume estimates and DOC concentration data collected under the MWQI Program since 1982. The historical and regional distribution of DOC has been studied and reported in previous MWQI reports. Mass load estimation work will begin in February 1998. Delta areas with the highest organic carbon loads discharged into the delta channels will be identified.

Brown and Caldwell engineers completed a study for MWQI on the treatment of delta island drainage in 1997. The study found that a reduction of up to 60 percent could be achieved by conventional coagulation/flocculation processes. Fallowing land could be another option. The options will be developed on the basis of proximity to water supply intakes, dominant water circulation patterns in the delta, and size of DOC mass load from each island or subregion. A candidate list of islands or regions for organic carbon reduction will be developed.

The regional distribution of DOC in the delta was discussed in the MWQI Five-Year Report for January 1987 - December 1991 (DWR, 1994). Further analysis of MWQI data will be performed to develop expected monthly DOC values across the regions of the delta. These values will be used with monthly drainage volume estimates to compute monthly mass loads of DOC discharged from the delta islands. As with drainage volume estimates, we expect to generate more than one set of DOC concentration values to be used in the modeling work because of different water year classifications and conditions.

**Goal: Model Runs of Drainage Control Options**

***Proposed Report: Water Quality Benefits from Controlling Delta Island Drainage***  
***Completion Date: 8/1/98***

The Delta Modeling Group will run predictive delta water quality models on various scenarios we define that cover the above spectrum of alternatives for the delta. In turn, the results will be used to help us develop other alternatives. For example, modeled results might show only slight improvement in water quality by reducing organic loads from three islands. Another model run that simulates more islands under treatment or intake relocation might be result in better water quality. There will be interaction between MWQI and Delta Modeling staff in refining possible alternatives.

The Delta Water Treatment and Costs Model for THM Control, developed by Malcolm-Pirnie for MWQI, will then be used to assess the cost of treating the resulting modeled water quality.

**2. DESIGNING WETLANDS AND SHALLOW WATER STORAGE FACILITIES**

**Goal: Study of Factors Affecting Organic Carbon Availability from Flooded Environments (Wetlands and Water Storage)**

***Proposed Report: Progress Report - Experiment 1: Water Depth, Water Flow, and Peat Soil Depth Effects on DOC Availability***  
***Completion Date: June 15, 1998***

Initial experiments at the new SMARTS facility will be conducted to study the major factors that may affect DOC in waters overlying peat soil from wetlands creation and water storage on delta islands. The experimental protocol will be a full or partial factorial experimental design or response surface methodology. The information will be used to design and operate such projects with minimal impact on drinking water quality, specifically organic carbon concentrations. Iterations of the experiments are necessary and peat soil may be substituted with other soil types.



to study out-of-delta water storage options. Other follow-up experiments might examine TOC contributions from algae, decaying crop biomass, and wetland plants.

The results will be used to develop a computer model. Results of the SMARTS experiments may develop a model that relates the mass load of TOC to different water flow rates and water depth. Commercial software such as Model Maker will be used by the MWQI water quality consultant.

**Goal: Assessing Organic Carbon Loads from Wetland and Water Storage Projects**

***Proposed Report: Model Runs of Proposed Wetland and Water Storage Projects in the Delta***  
***Completion Date: December 1, 1998***

Computer model runs of hypothetical wetlands and water storage facilities in the delta (e.g., flooded islands) will be performed.

**3. EXAMINING WATER SUPPLY INTAKE OPTIONS**

**Goal: Examine Water Quality at Proposed Water Supply Intakes**

***Proposed Report: Historical Data Report, MWQI 1982 - 1997***  
***Completion Date: 1998***

Channel water quality data collected since 1982 will be summarized and interpreted. The report will describe the history, mission, and milestones of the Interagency Delta Health Aspects Monitoring Program and MWQI Program. Data analysis will primarily focus on the water quality parameters that are needed in the Delta Water Treatment and Costs Model for THM Control. The analysis will provide input data sets for the model runs.

Data needs will be identified and further data collection needs will be recommended to the MWQI Program for monitoring.

**Goal: Assess Water Supply Intake Location Options**

***Proposed Report: Model Runs of Water Quality Benefits from Various Water Supply Intake Locations***  
***Completion Date: 1998 - early 1999***

Computer model runs using historical and predicted water quality data for various potential water supply intakes in the delta will be performed.

#### 4. ALTERNATIVES ASSESSMENT

##### Goal: Develop Candidate Delta Alternatives

*Proposed Report: Summary Report of Candidate Water Transfer and Storage Alternatives to Improve Drinking Water Quality in the Delta*  
*Completion Date: 1999-2000*

Additional as needed SMARTS experiments, computer model runs, delta water quality monitoring, and refinements to delta alternative scenarios are expected to continue into 1998-99. A final report will summarize the predicted water quality benefits from the computer model runs of the modeled delta alternatives and combinations of scenarios.

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# Modeling Delta Alternatives to Improve Drinking Water Quality

## Schedule of Tasks

TASK	Start Date	Duration(days)	End Date
Delta Island Drainage Estimates Report	12/1/97	45	1/14/98
Candidate Delta Regions for TOC Reduction	2/15/98	45	3/31/98
Drainage Treatment Model Runs	4/1/98	60	5/30/98
W.Q. Benefits from Controlling Drainage TOC Report	6/1/98	60	7/30/98
SMARTS Construction Final Phase	3/1/98	30	3/30/98
SMARTS Expt. 1 and Report	4/1/98	120	7/29/98
SMARTS Expt. 2 and Report	8/1/98	160	1/7/99
Flooded Island Model Runs	9/1/98	60	10/30/98
W.Q. Assessment of Flooded Islands Report	11/1/98	60	12/30/98
Historical Water Quality Data Report	3/1/98	120	6/28/98
Water Supply Intake Model Runs	7/1/98	60	8/29/98
W.Q. at Delta Intakes Report	9/1/98	60	10/30/98
Final Alternatives Assessment Report	11/2/98	60	12/31/98

September 3, 1998

TO: Rick Woodard

RE: Questions for Expert Panel on CALFED Water Quality Issues

**Objective:** provide healthy drinking water while minimizing adverse effects on ecological resources.

Questions for the panel:

1. What is a systematic approach to meeting the above objective? We define the system as ranging from the Sierra Nevada to the taps in both northern and southern California?

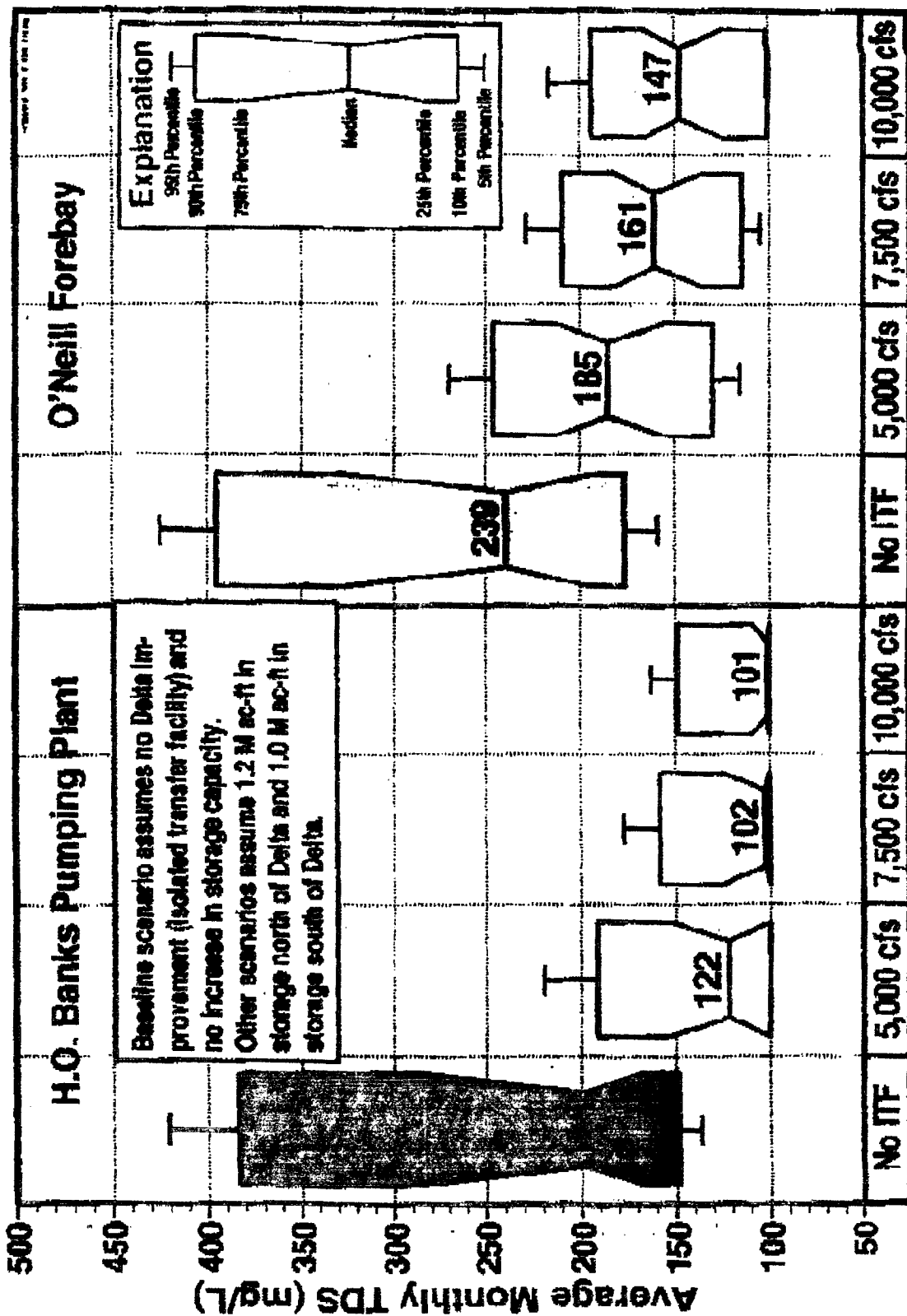
We assume that variables to be incorporated and optimized include: a) options for reducing bromide AND OTHER ADVERSE CONSTITUENTS at the primary intake (isolated facility, freshwater releases, seasonal timing of intake); b) manipulation of storage and distribution system (reoperation of existing above- and below-ground storage in combination with seasonal timing of pumping, options for blending other water sources including stored water); c) options for managing DISINFECTION treatment processes and other treatment systems.

Perspective: Water entering the plant plus treatment equals drinking water quality. Drinking water quality does not equal delta water quality.

2. What can be done by CALFED and/or the utilities using Delta waters to meet the regulatory and public health objectives for drinking water to be implemented within the next decade? This question addresses both source water improvements and treatment alternatives in combination to meet these objectives. It assumes that any water quality improvements from the CALFED conveyance or storage alternatives would not be available.

3. Given the uncertainties in predicting future drinking water health effects from bromates (and other constituents of concern), possible treatment technologies, and regulatory requirements, what approaches are most cost-effective for CALFED and/or utilities to pursue in protecting public health 20 years from now? These approaches should not be limited solely to the consideration of existing Delta water quality, but must include improvements to Delta water quality, combinations of physical and chemical treatment alternatives, and options for re-operating existing water supply facilities.

# Predicted TDS Levels at H.O. Banks PP and O'Neill Forebay for Various Capacities of Isolated Transfer Facility

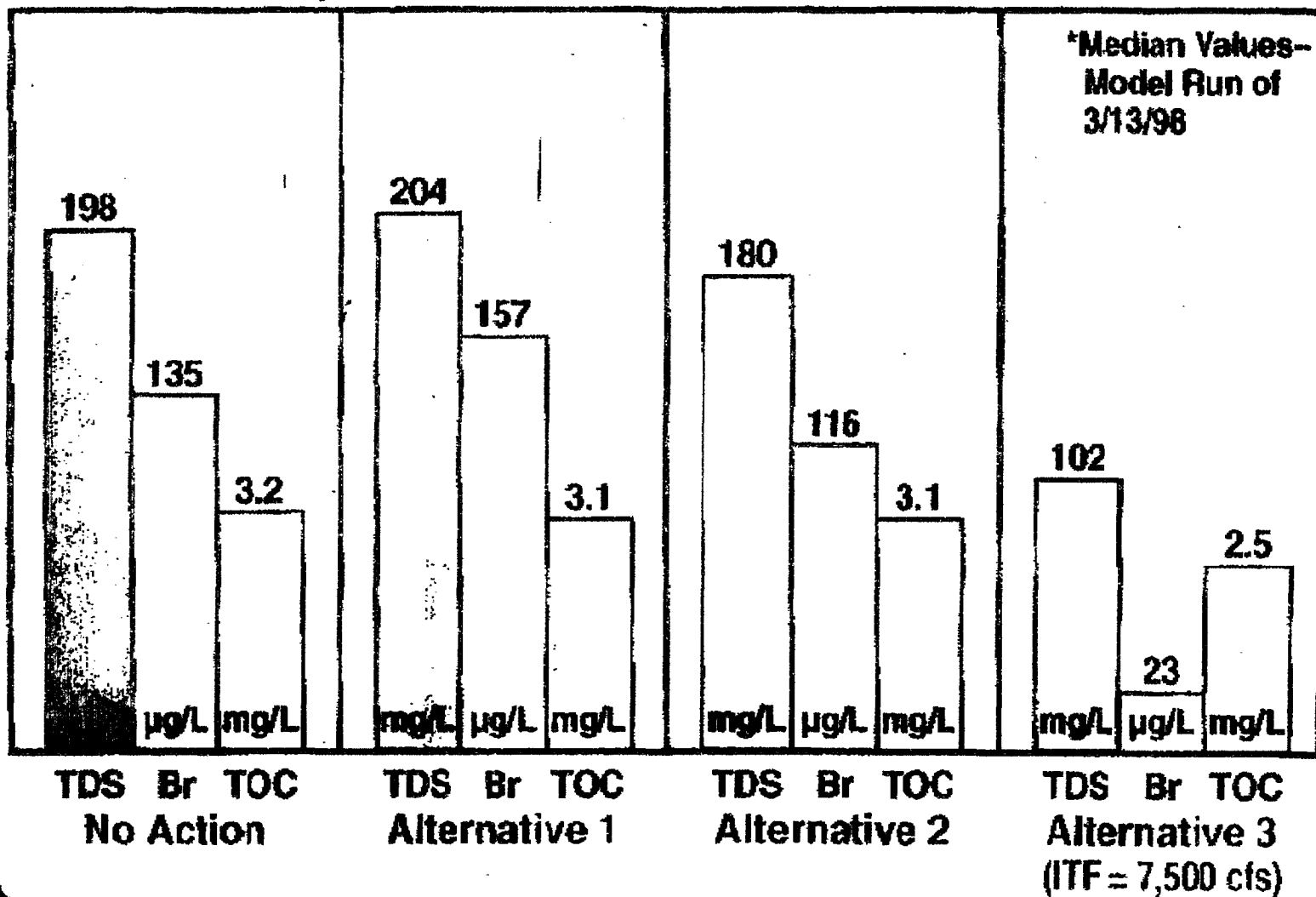


# Water Quality\* at O'Neill Forebay for CALFED Alternatives

No Action			Alternative 1			Alternative 2			Alternative 3		
TDS	Br	TOC	TDS	Br	TOC	TDS	Br	TOC	TDS	Br	TOC
239	205	3.3	256	249	3.2	201	138	3.2	161	90	2.9
mg/L	µg/L	mg/L	mg/L	µg/L	mg/L	mg/L	µg/L	mg/L	mg/L	µg/L	mg/L

\*Median Values-  
Model Run of  
3/13/98

# Water Quality\* at H.O. Banks PP for CALFED Alternatives



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